AGRICULTURAL DRAINAGE CONTRIBUTION TO WATER QUALITY IN THE GRASSLAND AREA OF WESTERN MERCED COUNTY, CALIFORNIA: October 1989 through September 1990

(WATER YEAR 1990)

California Regional Water Quality Control Board
Central Valley Region
3443 Routier Road, Suite A
Sacramento, California 95827-3098

January 1991

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

The Staff Involved in the
Preparation of This Report Are:

Dennis W. Westcot, Senior Land and Water Use Analyst
Jeanne E. Chilcott, Associate Land and Water Use Analyst
Cassandra A. Enos, Assistant Water Resources Specialist

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY AND RECOMMENDATIONS

SUMMARY

In May 1985, Regional Board staff began a water quality monitoring program to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area of western Merced County. The purpose of this monitoring program was to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. This database will be used in the development and evaluation of future agricultural drainage reduction programs in the San Joaquin River Basin. Reports on this water quality survey have already been prepared and approved by the Board for May 1985 through September 1989. The current report covers October 1989 through September 1990, a time period which includes critically dry Water Year 1990, and provides a long-term data base for assessing the effects of future regulatory actions.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) or Salt Slough and ultimately the San Joaquin River. A water quality monitoring network was established to ensure measurement of inflows to the Grassland Area, internal flows within the Grassland, and outflows to the San Joaquin River.

The current study shows that water quality continues to vary widely with the highest constituent concentrations found at the inflow monitoring stations near the southern boundary of the study area. This inflow water is generally a blend of subsurface tile drainage and surface runoff (tailwater) or operational spills from irrigation canals. Four of these inflow points carry a substantial portion of subsurface drainage water. The highest concentrations at these four sites likely reflect a greater proportion of tile drainage in the flow and not necessarily the quality of subsurface drainage being discharged at the tile drainage sumps. The sites inflowing from the south and southeast continue to carry the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium; however, elevated levels of salt and boron are present. For example, the median values for selenium at the four major southern inflow points ranged from 52 to 84 μg/L while other inflow points showed selenium values ranging from 2.3 to 54 μg/L. For boron however, the four drains carrying the high selenium water showed median boron values ranging from 3.5 to 7.5 mg/L while the other inflow drains that have low selenium values showed median boron values ranging from 0.3 to 8.4 mg/L.

Concentration at the internal flow and outflow monitoring stations were comparable to each other and were substantially lower than the southern inflows. The water quality reflects the amount of mixing and dilution that takes place as drainage water moves through the Grassland Area. The flows are strongly regulated by an extensive system of man-made structures, and trends in water quality are difficult to identify.

The two main outflows, Mud Slough (north) and Salt Slough, were monitored during the study. These sites represent water quality of the blended drainage flowing from the Grassland Area to the San Joaquin River. The quality of both sloughs varied widely depending upon which slough was carrying the greatest portion of subsurface tile drainage water. The median selenium concentration for Salt Slough was higher than that of Mud Slough although a wide range of variability was detected. For example, Salt Slough selenium concentrations ranged from 3.6 to 36 μg/L with a median of 15 μg/L. Mud Slough showed a similar variability with a median selenium value of 5.1 μg/L. Concentrations for all the drains and sloughs were routinely higher during the critical Water Years 1987-90 than they were during the wet Water Year 1986. Seasonal variations in constituent concentrations occurred in Water Year 1990 in a manner similar to the previous four Water Years, with the highest levels occurring during the non-irrigation season (October to March).

Water quality objectives for selenium, molybdenum and boron have been adopted by the Central Valley Regional Board and approved by the State Water Resources Control Board for both Mud Slough (north) and Salt Slough. Compliance for the objectives is set for 1993. Milestones have been included for selenium for WYs 90, 91 and 92 to evaluate progress toward meeting the objective.

During WY 90, the 1993 monthly mean molybdenum objective (19 μg/L) was only exceeded on one occasion in Mud Slough and was not exceeded at any time in Salt Slough. In contrast, the 1993 mean monthly boron objective (2.0 mg/L) was consistently exceeded in both sloughs during WY 90.

The selenium milestone for WY 90 (20 μg/L) was exceeded between January and June 1990 in Salt Slough with the maximum monthly mean reaching 29 μg/L. Mud Slough did not exceed the 1990 milestone for selenium during WY 90.

The upcoming 1993 water quality objective for selenium (10 μg/L) was exceed during WY 90 by both Mud Slough (north) and Salt Slough. Continuing drought conditions during WY 91 may increase difficulties in meeting future milestones and objectives for both sloughs.

The monthly mean concentrations of boron, molybdenum, and selenium will continue to be reviewed in future water years.

RECOMMENDATIONS

1. In cooperation with other agencies and dischargers, continue water quality monitoring at the inflow points to the Grassland Area in order to expand the database needed to evaluate the effectiveness of the drainage reduction programs being developed for the Western San Joaquin Valley;

2. Reduce or eliminate the internal flow stations within the Grassland Area as operation and management play a major role in their water quality;

3. In cooperation with other agencies, ensure continued water quality and flow monitoring at the two main outflow stations (Mud Slough (north) and Salt Slough) to the San Joaquin River;

4. Continuous flow monitoring equipment should be installed on the four main inflow drains to the South Grassland Area which are not presently gauged to aid evaluation of future agricultural drainage reduction programs in the San Joaquin River Basin.

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program in May of 1985 to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area in western Merced County. The study area is located west of the San Joaquin River between Newman and Oro Loma, California (Figure 1). The purpose of this monitoring program was to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. This database will be used in the development and evaluation of an agricultural drainage reduction program in the San Joaquin River Basin. This report contains laboratory results and a brief summary of the water quality analysis for samples collected from October 1989 through September 1990. Three previous reports (James et al., 1988, Chilcott et al., 1989, and Westcot et al., 1990) present data for the period May 1985 through September 1989. This report is a discussion of the entire Water Year (WY) 90 which extends from October 1, 1989 through September 30, 1990.

STUDY AREA

The Grassland Area is comprised of the Northern and Southern Divisions of the Grassland Water District and the farmlands adjacent to the District (Figure 1). Land in this area is primarily used for agriculture and seasonal wetlands for wildlife.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) or Salt Slough and ultimately the San Joaquin River.

There were 32 stations in the Grassland monitoring program as described by James et al., 1988. They were divided into three categories: inflows to, internal flows within, and outflows from the Grassland Area. Inflow monitoring stations were located on drains that discharge into the Grassland area and are mainly located at the southern end of the study area. Monitoring stations on the internal flow canals were located on drains within the Grassland Area that carry or could carry subsurface tile drainage as it passes through the area before discharging to the San Joaquin River. Outflow monitoring stations were located where drains or natural waterways flow out of the Grassland Area. Many of the internal flow stations described by James et al. (1988), have been dropped from the monitoring program due to the large effect management plays in their water quality. The present report concentrates on the inflow and outflow stations. A list of the monitoring stations is shown in Table 1. Stations which have continuous data from May 1985 through September 1990 have been highlighted. The remaining stations were dropped from the monitoring program prior to October 1989 with the corresponding data reported in James et al. 1988, Chilcott et al., 1989 and Westcot et al., 1990. In this study, there are 11 inflow, 2 internal flow, and 4 outflow monitoring stations. The two internal flow stations are maintained to assess the approximate concentration of selenium in the two main water supply source canals to the Grassland Area. Table 1 also identifies the map index number for each site as shown on the location map in Figure 2.

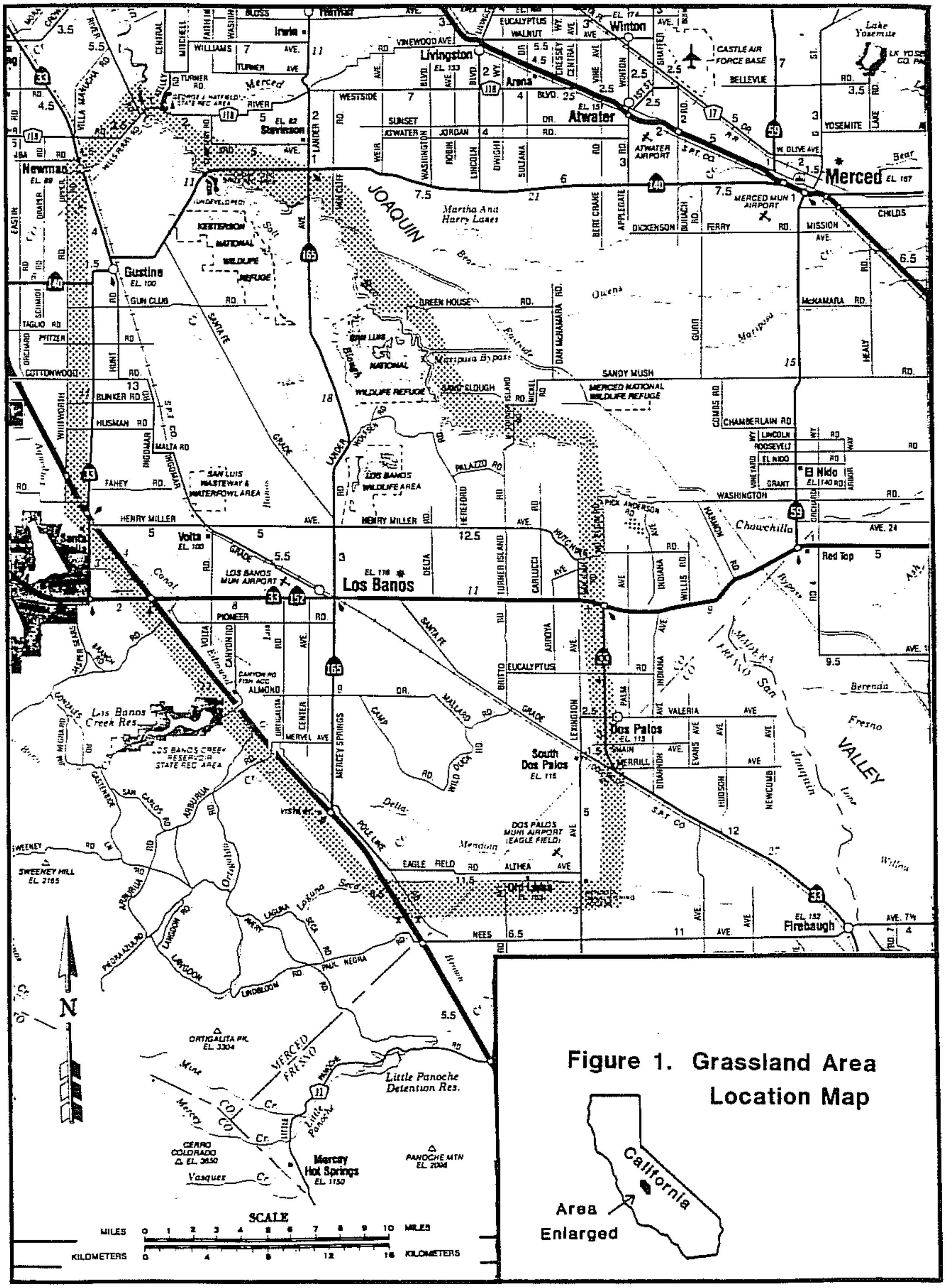


Figure 1. Grassland Area Location Map

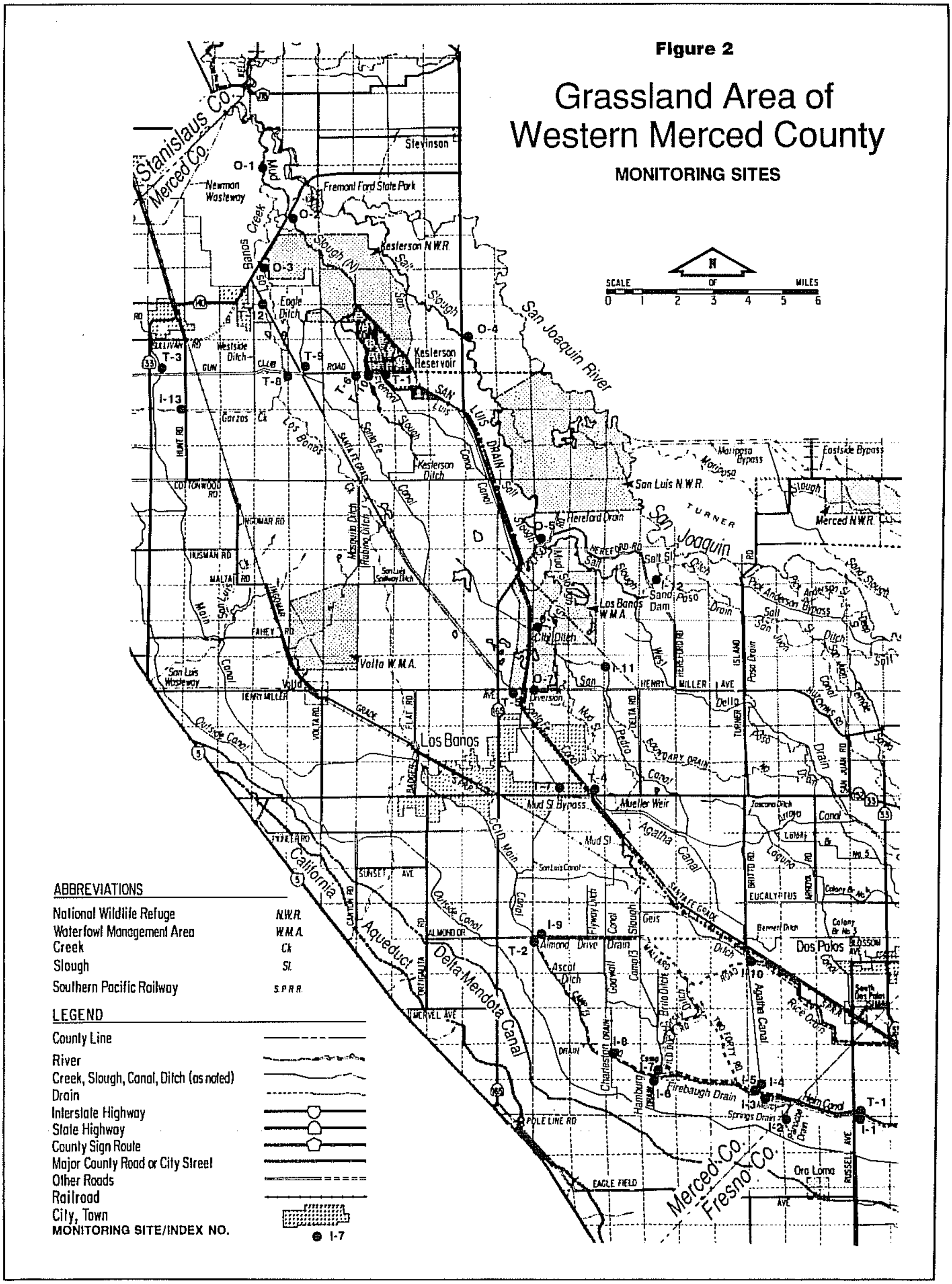


Figure 2

Grassland Area of Western Merced County

MONITORING SITES

Table 1. Water Quality Monitoring Sites in the Grassland Area (adapted from James et al., 1988 and Chilcott et al., 1989).

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	**MER556**	**Main (Firebaugh) Drain @ Russell**	**Inflow**
I-2	**MER501**	**Panoche Drain**	**Inflow**
I-3	**MER552**	**Agatha Inlet (Mercy Springs) Drain**	**Inflow**
I-4	**MER506**	**Agatha Canal**	**Inflow**
I-5	MER507	Helm Canal	Inflow
I-6	**MER504**	**Hamburg Drain**	**Inflow**
I-7	**MER505**	**Camp 13 Slough**	**Inflow**
I-8	**MER502**	**Charleston Drain**	**Inflow**
I-9	**MER555**	**Almond Drive Drain**	**Inflow**
I-10	**MER509**	**Rice Drain**	**Inflow**
I-11	**MER521**	**Boundary Drain**	**Inflow**
I-12	**MER528**	**Salt Slough Ditch @ Hereford Road**	**Inflow**
I-13	MER513	Garzas Creek @ Hunt Road	Inflow
T-1	**MER510**	**CCID Main @ Russell Avenue**	**Internal Flow**
T-2	MER511	CCID Main @ Almond Drive	Internal Flow
T-3	MER512	CCID Main @ Gun Club Road	Internal Flow
T-4	MER540	Santa Fe Canal @ HWY 152	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Rd.	Internal Flow
T-6	MER517	Santa Fe Canal @ Gun Club Rd.	Internal Flow
T-7	**MER527**	**San Luis Canal @ HWY 152**	**Internal Flow**
T-8	MER514	Los Banos Creek @ Gun Club Rd.	Internal Flow
T-9	MER518	Eagle Ditch	Internal Flow
T-10	MER516	Mud Slough (North) @ Gun Club Rd.	Internal Flow
T-11	MER515	Freemont Canal @ Gun Club Rd.	Internal Flow
T-12	MER553	Gustine Sewage Treatment Plant Ditch	Internal Flow
O-1	**MER551**	**Mud Slough (N) @ Newman Gun Club**	**Outflow**
O-2	**MER541**	**Mud Slough (N) @ HWY 140**	**Outflow**
O-3	**MER554**	**Los Banos Creek @ HWY 140**	**Outflow**
O-4	**MER531**	**Salt Slough @ Lander Avenue**	**Outflow**
O-5	MER530	Salt Slough @ Wolfsen Road	Outflow
O-6	MER543	City Ditch	Outflow
O-7	MER548	Santa Fe Canal-Mud Slough Diversion	Outflow

Bold print indicates that site has data for WY 90

METHODS

The frequency of sample collection for this phase of the monitoring program varied, but generally grab samples were collected during the first week of each month and were analyzed for total recoverable selenium, boron, chloride, sulfate, hardness and electrical conductivity (EC). Because of the continued drought conditions throughout WY 90, weekly sampling was conducted at outflow sites O-2 and O-4 (Table 1). Selected inflow and outflow monitoring sites were also sampled for total recoverable copper, chromium, lead, molybdenum, nickel, and zinc. Water temperature, pH, EC, and sample time were recorded in the field for each site. All samples were collected in polyethylene bottles. All the selenium and trace element sample bottles were washed and acid rinsed in the laboratory prior to use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium and trace element samples were preserved by lowering the pH to less than 2 using ultra-pure nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.

Table 1. Water Quality Monitoring Sites in the Grassland Area
(adapted from James et al., 1988 and Chilcott et al., 1989).

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	**MER556**	**Main (Firebaugh) Drain @ Russell**	**Inflow**
I-2	**MER501**	**Panoche Drain**	**Inflow**
I-3	**MER552**	**Agatha Inlet (Mercy Springs) Drain**	**Inflow**
I-4	**MER506**	**Agatha Canal**	**Inflow**
I-5	MER507	Helm Canal	Inflow
I-6	**MER504**	**Hamburg Drain**	**Inflow**
I-7	**MER505**	**Camp 13 Slough**	**Inflow**
I-8	**MER502**	**Charleston Drain**	**Inflow**
I-9	**MER555**	**Almond Drive Drain**	**Inflow**
I-10	**MER509**	**Rice Drain**	**Inflow**
I-11	**MER521**	**Boundary Drain**	**Inflow**
I-12	**MER528**	**Salt Slough Ditch @ Hereford Road**	**Inflow**
I-13	MER513	Garzas Creek @ Hunt Road	Inflow
T-1	**MER510**	**CCID Main @ Russell Avenue**	**Internal Flow**
T-2	MER511	CCID Main @ Almond Drive	Internal Flow
T-3	MER512	CCID Main @ Gun Club Road	Internal Flow
T-4	MER540	Santa Fe Canal @ HWY 152	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Rd.	Internal Flow
T-6	MER517	Santa Fe Canal @ Gun Club Rd.	Internal Flow
T-7	**MER527**	**San Luis Canal @ HWY 152**	**Internal Flow**
T-8	MER514	Los Banos Creek @ Gun Club Rd.	Internal Flow
T-9	MER518	Eagle Ditch	Internal Flow
T-10	MER516	Mud Slough (North) @ Gun Club Rd.	Internal Flow
T-11	MER515	Freemont Canal @ Gun Club Rd.	Internal Flow
T-12	MER553	Gustine Sewage Treatment Plant Ditch	Internal Flow
O-1	**MER551**	**Mud Slough (N) @ Newman Gun Club**	**Outflow**
O-2	**MER541**	**Mud Slough (N) @ HWY 140**	**Outflow**
O-3	**MER554**	**Los Banos Creek @ HWY 140**	**Outflow**
O-4	**MER531**	**Salt Slough @ Lander Avenue**	**Outflow**
O-5	MER530	Salt Slough @ Wolfsen Road	Outflow
O-6	MER543	City Ditch	Outflow
O-7	MER548	Santa Fe Canal-Mud Slough Diversion	Outflow

Bold print indicates that site has data for WY 90

METHODS

The frequency of sample collection for this phase of the monitoring program varied, but generally grab samples were collected during the first week of each month and were analyzed for total recoverable selenium, boron, chloride, sulfate, hardness and electrical conductivity (EC). Because of the continued drought conditions throughout WY 90, weekly sampling was conducted at outflow sites O-2 and O-4 (Table 1). Selected inflow and outflow monitoring sites were also sampled for total recoverable copper, chromium, lead, molybdenum, nickel, and zinc. Water temperature, pH, EC, and sample time were recorded in the field for each site. All samples were collected in polyethylene bottles. All the selenium and trace element sample bottles were washed and acid rinsed in the laboratory prior to use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium and trace element samples were preserved by lowering the pH to less than 2 using ultra-pure nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.

A quality control and quality assurance program was conducted utilizing spike and duplicate samples in the laboratory. In addition, blind replicate samples were collected at 10 percent of the sites, and 50 percent of the blind replicates were spiked for laboratory quality assurance. Reported results fall within quality assurance tolerance guidelines outlined in Regional Board laboratory quality control files.

RESULTS

Following the trend described in James et al. (1988), Chilcott et al. (1989) and Westcot et al. (1990), the highest concentrations of the measured constituents were found at the inflow monitoring stations near the southern boundary of the study area. Concentrations at the internal flow and outflow monitoring stations were comparable to each other and were substantially lower than the southern inflows. Water quality analysis results at the inflow, internal flow, and outflow monitoring stations will be discussed separately.

Water quality results for both minerals and trace elements are listed by site in Appendices A through C; Grassland inflows (Appendix A), internal flows (Appendix B), and outflows (Appendix C). The ranges and median values for each measured constituent at each site are also shown in these appendices. For this study, electrical conductivity (EC) represented relative salinity, while boron, chloride, and sulfate were the primary mineral constituents of concern. Selenium and molybdenum were the primary trace elements of concern. The median mineral and trace element values at each inflow monitoring station are listed in Table 2 for WY 90 (October 1989 through September 1990).

Minerals

Inflow Monitoring Stations:

The inflow monitoring stations represent the quality of the agricultural drainage entering the Grassland Area as described in James et al. (1988). The first nine monitoring stations (I-1 to I-10) listed in Table 2 represent inflow into the South Grassland Area. The remaining two inflow stations (I-11 to I-12) either discharge to sloughs or the North Grassland Area (Figure 2).

Continuing the trend found in James et al. (1988), Chilcott et al. (1989), and Westcot et al. (1990), the inflows that carry a substantial portion of subsurface drainage water, the Main (Firebaugh) (I-1), Panoche (I-2), Agatha Inlet (Mercy Springs) (I-3), Hamburg (I-6), and Charleston Drains (I-8), had elevated salinity levels. The Agatha Inlet had the highest median EC (4910 μmhos/cm) and boron (8.4 mg/L) values. The highest median chloride concentration (720 mg/L) occurred in the Hamburg Drain. The Panoche, Agatha Inlet, Hamburg and Charleston Drains had median sulfate values of 1400 mg/L, while the Main Drain had a median sulfate value of 1200 mg/L.

Internal Flow Monitoring Stations:

The internal flow monitoring stations were located on drains that carry or could carry subsurface agricultural drainage as it passes through the Grassland Area as described in James et al. (1988). Only two of the original internal flow monitoring stations, the CCID Main at Russell Avenue (T-1) and the San Luis Canal at Highway 152 (T-7), were monitored during WY 90. These two stations represent concentrations in the main water supply source canals to the Grassland Area.

Table 2. Median Constituent Concentrations for Grassland Area Drains During WY 90 (10/89 through 9/90).

Map ID	Monitoring Site	umhos/cm EC	B	Cl	SO4	Hardness	Se	Mo	Cr	Cu	Ni	Pb	Zn
			Median Constituent Concentrations										
			-------mg/L-------				---ug/L---						
	Inflow Sites												
I-1	Main (Firebaugh) Drain @ Russell	3400	4.6	370	1200	720	52	24	10	5	11	<5	13
I-2	Panoche Drain/O'Banion	4550	7.5	665	1400	1100	72	8	32	4	9	<5	10
I-3	Agatha Main (Mercy Springs) Drain	4910	8.4	640	1400	1000	7.9	–	–	–	–	–	–
I-4	Agatha Canal	4040	6.6	480	1100	900	26	8	–	–	–	–	–
I-6	Hamburg Drain	4740	5.4	720	1400	1400	84	5	14	1	<5	<5	6
I-7	Camp 13 Slough	3440	4.9	455	1010	780	54	9	–	–	–	–	–
I-8	Charleston Drain	4350	3.7	525	1400	1150	69	6	14	3	8	<5	17
I-9	Almond Drive Drain	1320	0.91	155	220	270	2.3	–	–	–	–	–	–
I-10	Rice Drain	3050	5.4	350	855	740	2.7	16	–	–	–	–	–
I-11	Boundary Drain	1500	0.44	250	175	270	0.9	–	–	–	–	–	–
I-12	Salt Slough/Hereford	1030	0.30	160	110	230	0.6	–	–	–	–	–	–
	Internal Flow Sites												
T-1	CCID Main Canal/Russell	680	0.32	120	93	160	2.3	–	–	–	–	–	–
T-7	San Luis Canal/HWY 152	1400	1.7	180	270	310	2.5	–	–	–	–	–	–
	Outflow Sites												
O-1	Mud Slough / NGC	2480	2.1	335	510	505	4.3	10	–	–	–	–	–
O-2	Mud Slough/HWY 140	3060	3.4	410	590	520	5.2	12	6	2	8	<5	7
O-3	Los Banos Creek/HWY 140	1870	1.2	210	290	340	0.8	–	–	–	–	–	–
O-4	Salt Slough/Lander Ave.	2340	2.3	340	525	515	15	7	10	4	9	<5	15

All results are reported as total recoverable

The median EC, boron, chloride, and sulfate values recorded during this study for each of the internal flow monitoring stations are listed in Table 2.

Outflow Monitoring Stations:

Mud Slough (north) and Salt Slough are the only two tributaries to the San Joaquin River which drain the Grassland Area and are described in detail by James et al. (1988), Pierson et al. (1989a and 1989b). Mud Slough (north) at Highway 140 (O-2) and Salt Slough at Lander Avenue (O-4) are the principal stations in this monitoring program. These two sloughs best represents the water quality of the drainage leaving the Grassland Area. Los Banos Creek at Hwy 140 (O-3) drains into Mud Slough (north) upstream of the San Joaquin River. Mud Slough at Newman Gun Club (O-1) represents the combined quality of Mud Slough (north) and Los Banos Creek. During this study, Mud Slough (north) at Highway 140 had EC values ranging from 990 to 8940 μmhos/cm with a median of 3060 μmhos/cm. Boron at this site ranged from 0.60 to 5.8 mg/L with a median value of 3.4 mg/L.

Salt Slough at Lander Avenue (O-4) is the last monitoring station before Salt Slough discharges to the San Joaquin River. During this study, Salt Slough at Lander Avenue had EC values ranging from 1210 to 4050 μmhos/cm with a median value of 2335 μmhos/cm, and boron values ranging from 0.75 to 3.7 mg/L with a median of 2.3 mg/L (Appendix C). As seen in WY 1989 (Westcot et al., 1990), EC and boron concentrations at this site were less variable than in previous WYs because of the continuous use of this slough to divert drainage to the San Joaquin River. Concentrations at this site are generally lower than the South Grassland inflow monitoring stations due to additional dilution that occurs as the drainage water moves further downstream within the Grassland Area. Median concentrations for salinity and boron were lower in Salt Slough than in Mud Slough (north).

Trace Elements

Although selenium was monitored at every site and molybdenum at a majority of sites, analyses of additional trace elements were limited based on the overall low concentrations found by James et al. (1988). Total recoverable selenium, molybdenum, copper, chromium, lead, nickel, and zinc are listed in Appendices A through C for inflow, internal flow, and outflow monitoring stations, respectively. The ranges and median concentrations for each measured trace element constituent at each monitoring station are also listed in these appendices. The median trace element concentrations at each of the stations for WY 90 are tabulated in Table 2.

Inflow Monitoring Stations:

The highest median trace element concentrations occurred at the South Grassland inflow stations (I-1 to I-10), where the median selenium values ranged from 2.3 μg/L at Almond Drive Drain (I-9) to 84 μg/L at Hamburg Drain (I-6). The Main (I-1), Panoche (I-2), Hamburg (I-6), and Charleston (I-8) Drains had high median selenium concentrations; however, as with salinity and boron discussed earlier, the concentrations are highly dependent upon the amount of dilution water in the canal or drain at the time of sampling. Due to the continued drought, total recoverable selenium concentrations have been found in excess of 100 μg/L at the

Main Drain (1 time), Charleston Drain (2 times), Hamburg Drain (2 times), and Panoche Drain (4 times), indicating that little surface runoff was available for dilution at that time. These higher concentrations occurred primarily during the non-irrigation season (October - March) when drainage flows were very low and dilution water was scarce. Inflow sites which carry drainage from Sierra Nevada deposits (Rice Drain, Boundary Drain and Salt Slough at Hereford) continue to contain the lowest median selenium concentrations.

The Main Drain (I-1) and Rice Drain (I-10) had the highest median molybdenum concentrations at 24 μg/L and 16 μg/L, respectively. The remaining inflow drains had median molybdenum concentrations ranging from 5 μg/L to 9 μg/L.

In addition to selenium and molybdenum, copper, chromium, nickel, lead and zinc were analyzed at the four major subsurface drainage inflows (Main, Panoche, Hamburg and Charleston Drains). Only chromium appears consistently elevated with median values ranging from 14 μg/L to 32 μg/L (Table 2).

Internal Flow Monitoring Stations:

Selenium was the only trace element measured at both internal flow monitoring stations. From October 1989 through September 1990, CCID Main Canal at Russell Avenue (T-1) had selenium concentrations ranging from 0.7 μg/L to 76 μg/L with a median concentration of 2.3 μg/L. During the same period, selenium concentrations at San Luis Canal at Hwy 152 (T-7) ranged from 0.7 μg/L to 3.9 μg/L with a median concentration of 2.5 μg/L.

Outflow Monitoring Stations:

Selenium was monitored at all four outflow stations, molybdenum was monitored at three stations (O-1, O-2 and O-4), and copper, chromium, nickel, lead, and zinc were monitored at two outflow stations (O-2 and O-4) on a limited basis. The median trace element concentrations detected during this study are tabulated in Table 2.

The outflow monitoring stations, as mentioned earlier, are related to one of two tributaries of the San Joaquin River; the outflow through Salt Slough (site O-4) and those that outflow through Mud Slough (north), (sites O-1 through O-3) as described in James et al. (1988).

Selenium concentrations at the furthest downstream monitoring station on Salt Slough at Lander Avenue (O-4), ranged from 3.6 to 36 μg/L with a median of 15 μg/L.

Selenium concentrations at Mud Slough (north) at Highway 140 (O-2) ranged from 0.9 to 31 μg/L with a median of 5.1 μg/L. Los Banos Creek flows into Mud Slough (north) downstream of the Highway 140 monitoring station and it has a diluting effect on the Slough with respect to selenium as measured at the Newman Land and Cattle Company station (O-1). Los Banos Creek receives its flow from the western portion of the North Grassland Area and from areas west of the study area. The creek receives little subsurface drainage. In WY 90, selenium concentrations range from 0.4 to 2.0 μg/L with a median of 0.8 μg/L at the Los Banos Creek at Highway 140 station (O-3). The downstream Mud Slough (north) station (O-1) had lower selenium concentrations than site O-2 with values ranging from 0.6 to 8.1 μg/L and a median of 4.3 μg/L.

DISCUSSION

The current study shows that water quality within the Grassland Area continues to vary widely with the highest constituent concentrations found at the inflow monitoring stations near the southern border of the study area. This inflow water is generally a blend of subsurface tile drainage and surface runoff (tailwater) or operational spills from irrigation canals. Four of these inflow points (I-1, I-2, I-6, and I-8) carry a substantial portion of subsurface drainage water. The highest concentrations at these four sites likely reflect a greater proportion of tile drainage in the flow and not necessarily the quality of subsurface drainage being discharged at the tile drainage sumps. The sites inflowing from the south and southeast continue to carry the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium, however elevated levels of salt and boron are present. For example, the median values for selenium at the four major southern inflow points ranged from 52 to 84 μg/L while other southern inflow points showed median selenium values ranging from 2.3 to 54 μg/L. The three canals which carry drainage from Sierran deposits (I-10, I-11 and I-12) continue to show the lowest selenium concentrations with medians ranging from 0.6 μg/L to 2.7 μg/L. For boron, however, the four drains carrying the high selenium water showed median boron values ranging from 3.7 to 7.5 mg/L while the other inflow drains that have low selenium values showed median boron values ranging from 0.3 to 8.4 mg/L.

Concentration at the internal flow and outflow monitoring stations were comparable to each other and were substantially lower than the southern inflows. The water quality reflects the amount of mixing and dilution that takes place as drainage water moves through the Grassland Area. The flows are strongly regulated by an extensive system of man-made structures and trends in water quality are difficult to identify.

Data for this study includes information for Water Year 1990 (WY 90). WY 90 is the fourth consecutive critically dry water year. Tabulated in Table 3 are median constituent concentrations by water year for all the study monitoring sites since 1985. Median concentrations were listed for WY 85 where available, however the 1985 data set may be incomplete for some locations. Concentrations for all the drains and sloughs were routinely higher during the critically dry Water Years 1987-90 than during the wet Water Year 1986. The elevated concentrations may be due in part to increased influence of the shallow groundwater as well as a decrease in dilution from irrigation spill water or tail water runoff. The decrease in irrigation spill water or tail water may be due to more efficient use of limited supply water.

The few exceptions to the general increase in concentrations are the Agatha Canal, Charleston Drain, Almond Drive Drain, Rice Drain, Boundary Drain, and Los Banos Creek at Hwy 140. At various times of the year, the Agatha Canal can carry agricultural drainage (subsurface and tailwater), supply water (purchase and operational spill), or a mixture of the two. The Charleston Drain carries a substantial percent of subsurface agricultural drainage from the southwest portion of the study area. The Almond Drive Drain can also carry a mixture of agricultural drainage and supply water resulting in large variations of water quality. The Rice Drain and Boundary Drain provide inflow to the eastern portion of the study area and primarily drain Sierran deposits. Los Banos Creek is a natural stream channel which drains the coastal foothills but carries a substantial portion of tailwater and operational spill water. The lower observed concentrations during the critical water years have not been explained.

Table 3. Median Constituent Concentrations for Grassland Area Drains During Water Years 85, 86, 87, 88, 89 and 90 (Data for WY's 85, 86, and 87 from James et al., 1988, and for WY 88 from Chilcott et. al., 1989).

Map ID	Monitoring Site / Water Year	umhos/cm EC	Median Constituent Concentrations ---------mg/L--------- B	Cl	SO4	------ug/L------ Se	Mo	Cr	Cu	Ni	Pb	Zn
I-1	Main (Firebaugh) Drain @ Russell											
	Dry WY 85	2400	3.2	230	693	35	--	--	--	--	--	--
	Wet WY 86	2700	3.5	250	900	46	14	16	9	27	--	14
	Critical WY 87	2600	3.4	270	630	42	9	19	9	22	--	28
	Critical WY 88	3000	3.6	320	790	49	10	22	12	22	<5	29
	Critical WY 89	2980	3.9	315	835	49	13	17	9	19	<5	23
	Critical WY 90	3400	4.6	370	1200	52	24	10	5	11	<5	13
I-2	Panoche Drain/O'Banion											
	Dry WY 85	3500	6.5	460	985	38	3	--	--	--	--	--
	Wet WY 86	3400	5.8	390	800	56	6.1	26	5.5	15	--	15
	Critical WY 87	4375	7.8	550	1075	47	2.5	40	10	13	--	18
	Critical WY 88	3650	6.4	440	890	54	3	43	12	21	<5	29
	Critical WY 89	4180	6.5	520	1000	69	6	32	5	8.0	<5	11
	Critical WY 90	4550	7.5	665	1400	72	8	32	4	9	<5	10
I-3	Mercy Springs Drain (Agatha Inlet Drain)											
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	3300	7.2	360	1000	14	10	7	5	13	--	10
	Critical WY 87	3125	7.0	302	800	6	16	5	3	7	--	3
	Critical WY 88	4150	8.6	540	1300	7.9	39	10	5	15	<5	12
	Critical WY 89	3655	7.6	435	895	6.7	--	--	--	--	--	--
	Critical WY 90	4910	8.4	640	1400	7.9	--	--	--	--	--	--
I-4	Agatha Canal											
	Dry WY 85	2600	4.9	315	1100	26	1	--	--	--	--	--
	Wet WY 86	3300	5.6	400	900	44	<5	13	9	21	--	16
	Critical WY 87	3305	5.6	410	760	38	6	22	7	12	--	12
	Critical WY 88	3550	5.6	430	895	39	3	--	--	--	--	--
	Critical WY 89	880	0.36	130	100	2.9	2	--	--	--	--	--
	Critical WY 90	4040	6.6	480	1100	26	8	--	--	--	--	--
I-6	Hamburg Drain											
	Dry WY 85	3200	3.8	435	900	47	6	--	--	--	--	--
	Wet WY 86	3250	4.0	400	1000	51	4	13	5	10	--	13
	Critical WY 87	3345	3.7	420	925	58	<5	17	5	8	--	10
	Critical WY 88	3600	4.1	450	1050	56	4.5	11	5	<5	<5	6
	Critical WY 89	5120	5.7	660	1500	95	5	16	2	<5	<5	6
	Critical WY 90	4740	5.4	720	1400	84	5	14	1	<5	<5	6
I-7	Camp 13 Slough											
	Dry WY 85	2550	3.4	280	745	32	4	--	--	--	--	--
	Wet WY 86	2950	3.9	375	905	43	<5	14	7	20	--	16
	Critical WY 87	2650	3.7	280	590	43	6	30	11	13	--	19
	Critical WY 88	4400	6.2	500	1050	43	4	--	--	--	--	--
	Critical WY 89	3750	5.2	440	940	59	8	--	--	--	--	--
	Critical WY 90	3440	4.9	455	1010	54	9	--	--	--	--	--
I-8	Charleston Drain											
	Dry WY 85	3900	2.6	395	1275	48	--	--	--	--	--	--
	Wet WY 86	4500	4.7	510	1580	93	7.9	9	10	14	--	18
	Critical WY 87	3855	4.2	480	1035	79	2	32	12	22	--	50
	Critical WY 88	4450	4.5	520	1300	71	3	31	13	27	--	47
	Critical WY 89	4400	3.8	520	1400	66	3	25	12	17	<5	33
	Critical WY 90	4350	3.7	525	1400	69	6	14	3	8	<5	17
I-9	Almond Drive Drain											
	Dry WY 85	1520	1.6	160	340	2	--	--	--	--	--	--
	Wet WY 86	--	--	--	--	--	--	--	--	--	--	--
	Critical WY 87	1925	2.1	224	395	4.8	4.5	28	11	21	--	25
	Critical WY 88	2300	2.1	230	460	4.6	--	18	7	13	--	15
	Critical WY 89	2160	2.2	190	420	3.7	--	--	--	--	--	--
	Critical WY 90	1320	0.91	155	220	2.3	--	--	--	--	--	--
I-10	Rice Drain											
	Dry WY 85	2450	5.7	245	715	2.5	--	--	--	--	--	--
	Wet WY 86	3300	8.1	350	1080	3	14	5	6	23	--	13

Table 3 cont. Median Constituent Concentrations for Grassland Area Drains During Water Years 85, 86, 87, 88, 89 and 90 (Data for WY's 85, 86, and 87 from James et al., 1988, and for WY 88 from Chilcott et. al., 1989).

Map ID	Monitoring Site / Water Year	umhos/cm EC	mg/L B	mg/L Cl	mg/L SO4	ug/L Se	ug/L Mo	ug/L Cr	ug/L Cu	ug/L Ni	ug/L Pb	ug/L Zn
I-10	Rice Drain, cont'd											
	Critical WY 87	2500	6.1	260	550	2.6	11	3	3	6	--	<1
	Critical WY 88	2790	5.1	310	700	2.6	15	--	--	--	--	--
	Critical WY 89	2745	5.4	280	673	3.1	14	--	--	--	--	--
	Critical WY 90	3050	5.4	350	855	2.7	16	--	--	--	--	--
I-11	Boundary Drain											
	Dry WY 85	1090	0.45	195	135	1	--	--	--	--	--	--
	Wet WY 86	1710	0.65	250	210	1	6	2	7	9	--	14
	Critical WY 87	1250	0.54	200	145	1.6	4	<1	2	<5	--	3
	Critical WY 88	1470	0.50	230	180	1.4	6	--	--	--	--	--
	Critical WY 89	1435	0.53	240	190	1.0	--	--	--	--	--	--
	Critical WY 90	1500	0.44	250	175	0.9	--	--	--	--	--	--
I-12	Salt Slough @ Hereford											
	Dry WY 85	850	0.37	120	100	1	--	--	--	--	--	--
	Wet WY 86	785	0.33	100	99	1	<5	3	5	9	--	22
	Critical WY 87	1000	0.39	130	120	1.4	3	1	2	<5	--	2
	Critical WY 88	1150	0.38	160	140	1.2	5	--	--	--	--	--
	Critical WY 89	1070	0.36	160	140	1.2	--	--	--	--	--	--
	Critical WY 90	1030	0.30	160	110	0.6	--	--	--	--	--	--
T-1	CCID Main Canal @ Russell											
	Dry WY 85	430	0.21	72	35	<1	--	--	--	--	--	--
	Wet WY 86	385	0.21	53	47	1.3	<5	3	3	5	--	8
	Critical WY 87	570	0.28	65	58	2.2	<5	1	3	<5	--	3
	Critical WY 88	760	0.29	120	65	1.7	--	--	--	--	--	--
	Critical WY 89	700	0.26	94	68	1.7	--	--	--	--	--	--
	Critical WY 90	680	0.32	120	93	2.3	--	--	--	--	--	--
T-7	San Luis Canal @ HWY 152											
	Dry WY 85	1550	1.4	180	295	4.5	--	--	--	--	--	--
	Wet WY 86	1200	1.4	130	200	2	<5	4	4	10	--	9
	Critical WY 87	2630	3.4	260	520	4	<5	3	3	<5	--	7
	Critical WY 88	2550	3.6	280	570	3.9	--	--	--	--	<5	--
	Critical WY 89	1045	0.76	135	140	2.5	--	--	--	--	--	--
	Critical WY 90	1400	1.7	180	270	2.5	--	--	--	--	--	--
O-1	Mud Slough @ NGC											
	Dry WY 85	-	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	1800	2.0	215	330	4	5	9	5	11	--	15
	Critical WY 87	2600	2.4	300	420	5.1	13	7	4	10	--	1
	Critical WY 88	2480	2.2	330	440	4.7	--	--	--	--	--	--
	Critical WY 89	2310	1.7	325	385	2.1	--	--	--	--	--	--
	Critical WY 90	2480	2.1	335	510	4.3	10	--	--	--	--	--
O-2	Mud Slough @ HWY 140											
	Dry WY 85	2600	3.1	305	525	13	--	--	--	--	--	--
	Wet WY 86	2300	3.0	280	630	8.5	8	6	5	14	--	11
	Critical WY 87	2600	3.0	320	540	17	9	12	9	11	--	7
	Critical WY 88	2820	2.7	350	510	9.3	11	--	--	--	--	--
	Critical WY 89	3000	2.4	425	480	2.1	11	9.5	4.0	<5	11.5	12.0
	Critical WY 90	3060	3.4	410	590	5.2	12	6	2	8	<5	7
O-3	Los Banos Creek @ HWY 140											
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	2200	2.3	430	300	1	<5	6	8	18	--	17
	Critical WY 87	1855	1.6	215	215	1.4	--	--	--	--	--	--
	Critical WY 88	1690	1.2	230	210	1.1	--	--	--	--	--	--
	Critical WY 89	1630	1.0	240	200	0.9	--	--	--	--	--	--
	Critical WY 90	1870	1.2	210	290	0.8	--	--	--	--	--	--
O-4	Salt Slough @ Lander Ave.											
	Dry WY 85	1250	0.96	185	195	4.5	--	--	--	--	--	--
	Wet WY 86	1610	1.3	240	245	7.4	7	4	6	12	--	18
	Critical WY 87	1720	1.7	250	350	12	6	6	4	6	--	4
	Critical WY 88	1940	1.9	260	385	13	6	--	--	--	--	--
	Critical WY 89	2040	1.9	270	430	15	6	12.8	5.8	1.3	11.6	18.4
	Critical WY 90	2340	2.3	340	525	15	7	10	4	9	<5	15

Water Years (WY) run from 1 October through 30 September.

The two main outflows, Mud Slough (north) and Salt Slough were monitored during the study. These sites represent water quality of the blended drainage flowing from the Grassland Area to the San Joaquin River. The quality of both sloughs varied widely depending upon which slough was carrying the greatest portion of subsurface tile drainage water. During WY 90, Salt Slough appeared to carry the greatest portion of subsurface tile drainage water based on elevated selenium concentrations. The median selenium concentration in Salt Slough (15 μg/L) was considerably higher than that in Mud Slough (5.1 μg/L). However, a wide range of variability was detected in both sloughs. For example, Salt Slough selenium concentrations ranged from 3.6 to 36 μg/L, while Mud Slough selenium concentrations ranged from 0.9 to 31 μg/L. During wet WY 86, the median boron concentration at Salt Slough at Lander Avenue was 1.3 mg/L. During the drier years, WY 87-90, median concentrations increased to 1.7 mg/L, 1.9 mg/L, 1.9 mg/L and 2.3 mg/L, respectively. Although median boron concentrations did not increase directly for Mud Slough at Hwy 140, peak monthly concentrations were higher on a number of occasions.

Selenium followed a similar trend in Salt Slough and Mud Slough (north). Median values in Salt Slough increased from 7.4 μg/L to 12 μg/L, 13 μg/L, 15 μg/L and 15 μg/L for WY 86, WY 87, WY 88, WY 89, and WY 90, respectively. Selenium values in Mud Slough (north) also showed elevated selenium concentrations during the first two critically dry years with the highest median concentration in WY 87 (17 μg/L). WY 89 and WY 90 showed 2.1 μg/L and 5.2 μg/L median selenium concentrations in Mud Slough (north), concentrations below the wet WY median of 8.5 μg/L.

Figures 3 through 6 present boron and selenium concentrations for Mud Slough (north) and Salt Slough for selected Water Years. As can be seen in all four figures, the time of year patterns remain similar regardless of water year type. As shown in James et al. (1988), the concentrations in Salt Slough tend to increase during the non-irrigation period (October to March) and decrease during the irrigation period (April to September) (Figures 3 and 4). During the non-irrigation period, flows in the drains and canals consist mainly of shallow groundwater seepage and subsurface drainage. These two water types have been shown to contain elevated levels of a number of constituents including boron and selenium (Lowry et al., 1989; Deverel et al., 1984; and Chilcott et al., 1988). During the irrigation season, a large proportion of the flow in the Grassland Area drains consists of surface agricultural runoff (tailwater) which dilutes the subsurface agricultural drainage, thus lowering the boron and selenium concentrations. During the non-irrigation season, there is no surface runoff, so the drains carry a higher proportion of subsurface agricultural drainage, and consequently, boron and selenium values are higher. In comparison to wet WY 86, selenium and boron concentrations in Salt Slough during critical WY 89 and WY 90 did not decrease substantially during the irrigation season. The elevated concentrations may be due in part to lack of dilution water available during the consecutively critically dry years, as well as water management directing the majority of subsurface drainage into Salt Slough rather than equally utilizing both Salt and Mud Sloughs as was practiced during WY 86.

Boron and selenium concentrations in Mud Slough did not appear to be greatly effected by water year type (Figures 5 and 6). The overall concentrations remained the highest during the irrigation period. Extreme variability in the individual sample concentration (especially during WY 90) demonstrates the importance of water management and available dilution on the concentrations.

Figure 3. Boron Concentrations in Salt Slough @ Lander Ave. for Water Years 86, 89, 90

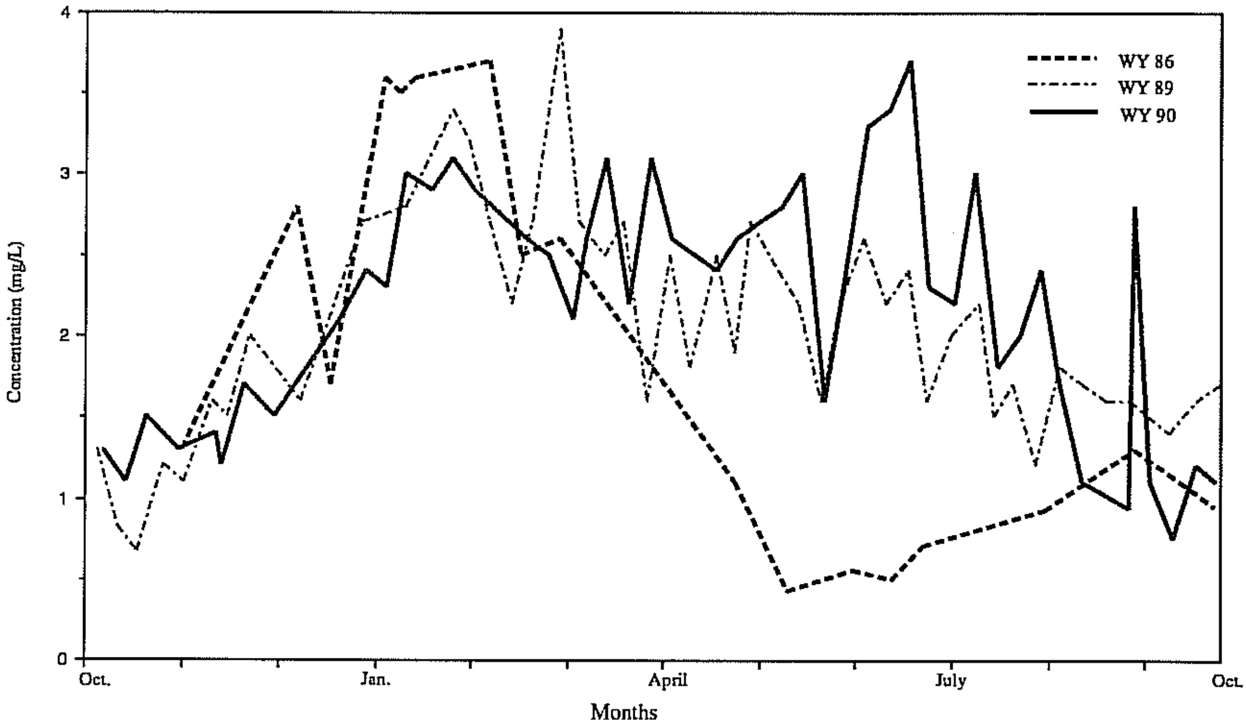


Figure 4. Selenium Concentrations in Salt Slough @ Lander Ave. for Water Years 86, 89, 90

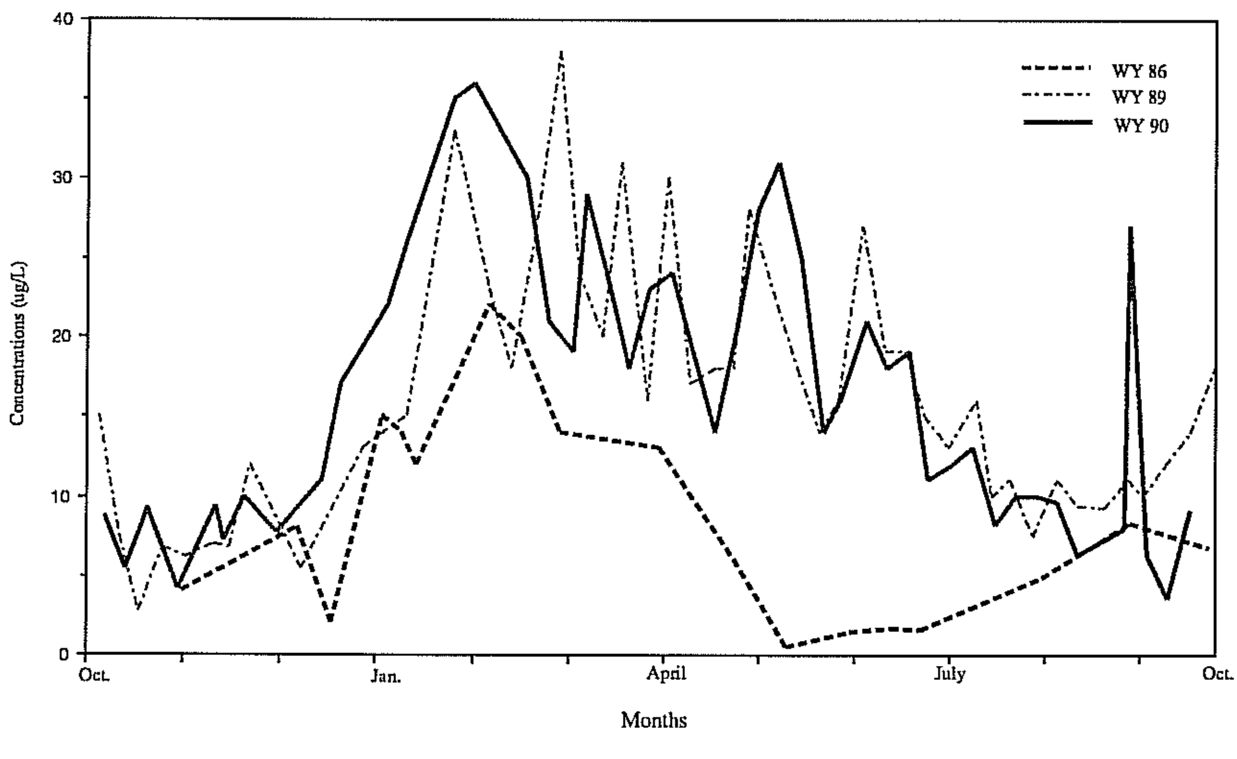


Figure 5. Boron Concentrations for Mud Slough (North) @ Hwy. 140 for Water Years 86, 89, 90

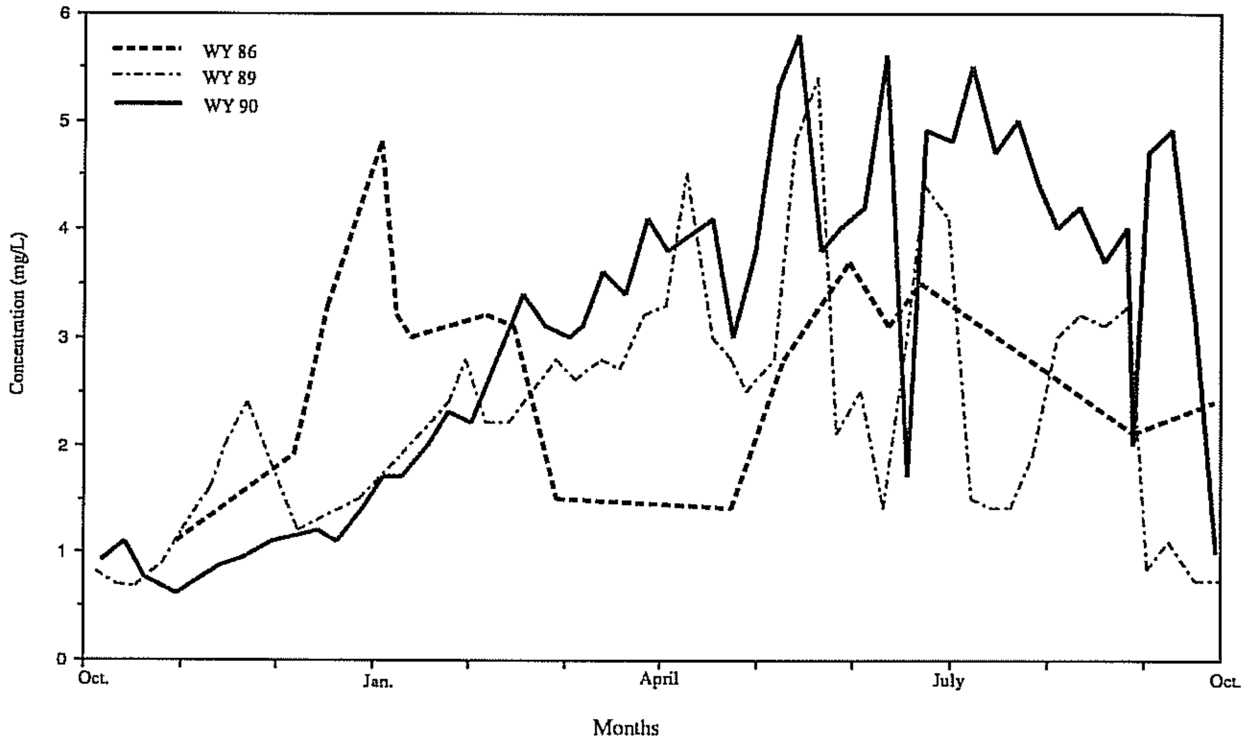
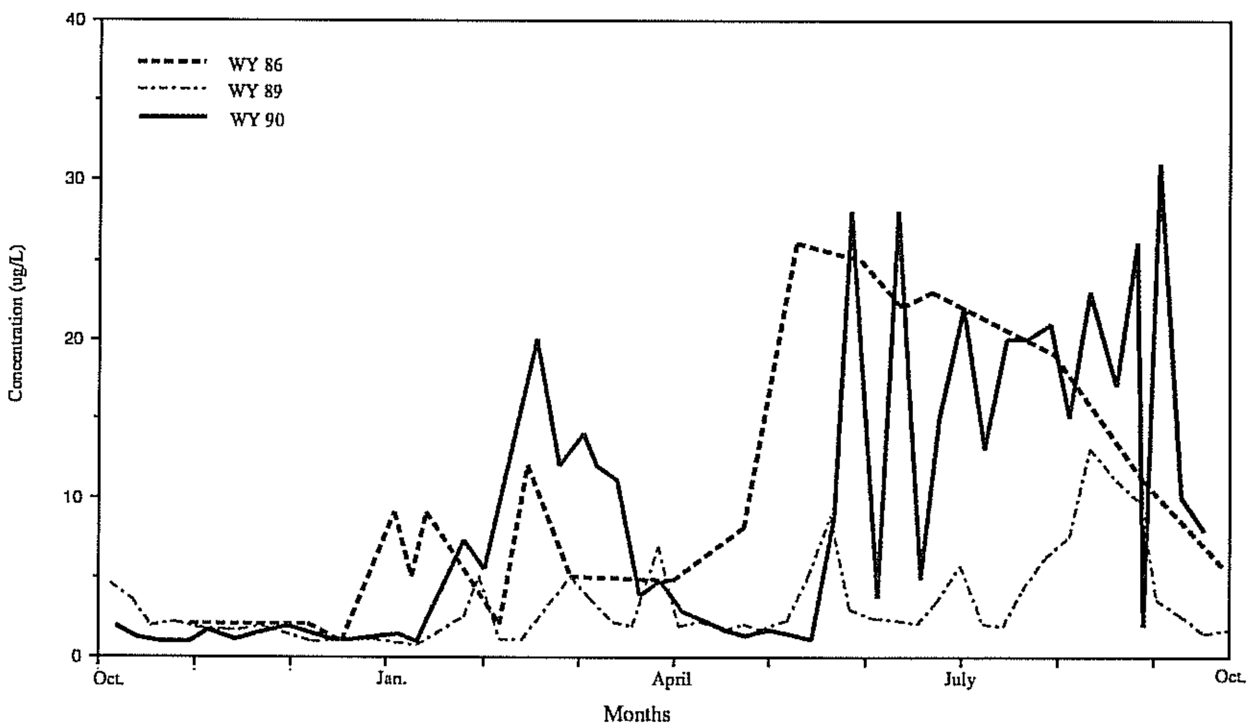


Figure 6. Selenium Concentrations in Mud Slough (North) @ Hwy. 140 for Water Years 86, 89, 90



Chromium continues to be an element of concern. Chromium is commonly found in shallow water in the western San Joaquin Valley south of the study area, especially in water derived from alluvial fan deposits (Deverel et al., 1984, and Chilcott et al., 1988). The highest chromium concentrations found in this monitoring program occurred in the Panoche Drain which receives its flow from areas with alluvial fan deposits. Ambient water quality criteria for chromium is based on concentrations of hexavalent chromium species. This monitoring program measured total recoverable chromium, therefore the current reported data can not be directly compared to the criteria. However, during WY 88, median values of total recoverable chromium routinely exceeded the four-day average ambient water quality criteria of 11 μg/L for the protection of freshwater aquatic life. Five of the eight drains monitored had median chromium concentrations exceeding 16 μg/L, the one-hour average hexavalent chromium criteria for protection of aquatic life (EPA, 1985). All the criteria values for the protection of freshwater aquatic life are based on acid soluble metals, whereas the trace element results in this study are total recoverable concentrations. For a given sample, the total recoverable concentrations are generally higher than acid soluble concentrations (Marshack, personal communication).

Since chromium is closely associated with the sediment, the monitoring program has been altered to analyze dissolved chromium as well as total recoverable chromium in downstream stations along the San Joaquin River. Analysis for acid soluble hexavalent chromium would be needed to evaluate the impact of chromium on the quality of water in these drains. A survey of hexavalent chromium at and upstream of inflow monitoring stations (areas where total chromium concentration appear the highest) has been conducted by Regional Board staff and will be reported separately.

COMPLIANCE WITH OBJECTIVES

In December 1988, the Regional Board adopted water quality objectives for the San Joaquin River and two of the River's tributaries, Mud Slough (north) and Salt Slough. Compliance dates were established for various concentrations of selenium, molybdenum and boron in the two sloughs (Table 4). These objectives and compliance dates were to be effective with the Regional Board adoption and approval of the objectives by the State Water Resources Control Board (State Board). State Board approval of the objectives and compliance dates was in September 1989, the last month of WY 89.

Table 4. Water Quality Objectives as Adopted by the Central Valley Regional Board for Mud Slough (north) and Salt Slough in the San Joaquin Basin (5C).

Constituent	Water Quality Objective		Compliance Date
Selenium	10 µg/L monthly mean	26 µg/L maximum	1993
Molybdenum	19 µg/L monthly mean	50 µg/L maximum	1990
Boron	2.0 mg/L monthly mean (15 March - 15 September)	5.8 mg/L maximum	1993

Figure 7. Mean Monthly Molybdenum Concentrations in Mud Slough (north) at Hwy. 140 and Salt Slough at Lander Ave. for WY 90, as Compared to the Adopted Water Quality Objective.

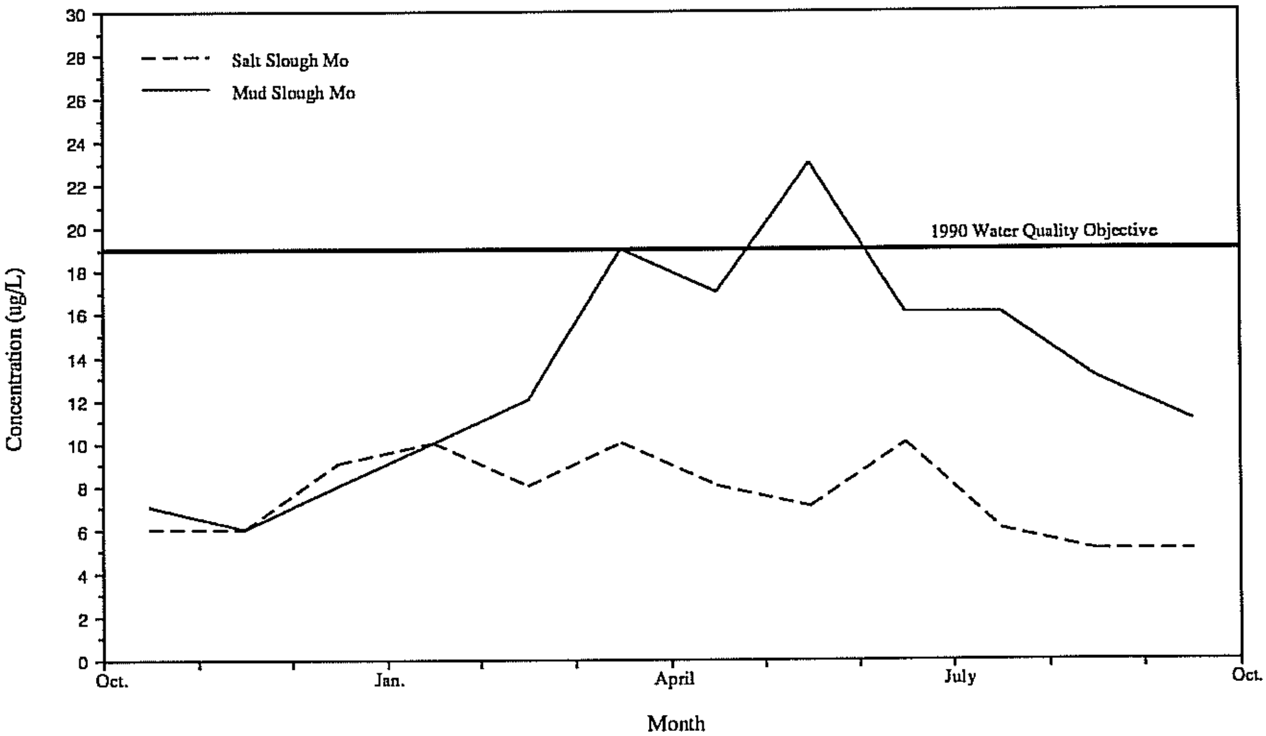
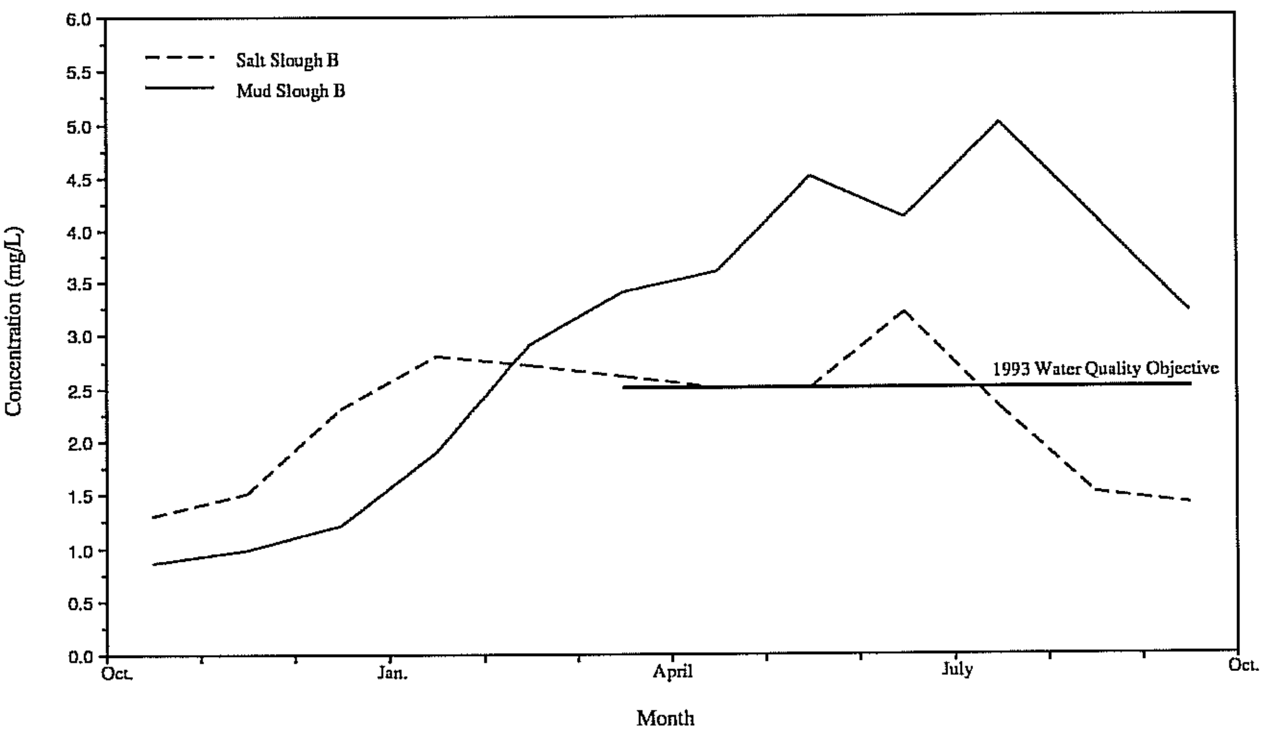


Figure 8. Mean Monthly Boron Concentrations in Mud Slough (north) at Hwy. 140 and Salt Slough at Lander Ave. for WY 90, as Compared to the Adopted Water Quality Objective.



As shown in Figure 7, the mean monthly molybdenum concentration objective (19 μg/L) was only exceeded on one occasion. A maximum monthly mean of 23 μg/L occurred during May 1990 in Mud Slough (north). The high molybdenum concentrations in May were likely due to natural seepage into Mud Slough. Little selenium was detected in the slough during that time period which indicates an absence of subsurface drainage. The corresponding high molybdenum and boron concentrations reflect the area's poor quality groundwater. Concentrations in Salt Slough remained below the objective during entire WY 90. The actual compliance date set to meet the objective was October 1990. The maximum concentration permitted (50 μg/L molybdenum) was not exceeded during WY 90.

The monthly mean water quality objective for boron (2.5 mg/L) was exceeded in both Mud Slough (north) and Salt Slough during WY 90 (Figure 8). Mud Slough (north) contained higher mean monthly boron concentrations. The maximum boron concentration (5.8 μg/L) was not exceeded during WY 90, although Mud Slough (north) did reach 5.8 μg/L on one occasion in May 1990. Although compliance with the objective is not until 1993, this comparison was made as no interim milestones are available for boron.

Water quality objectives for selenium were also approved by the State Board. In addition to the approved objectives, the following milestones were used to assess progress towards meeting the selenium water quality objectives in the two sloughs.

MAXIMUM MONTHLY MEAN SELENIUM CONCENTRATIONS

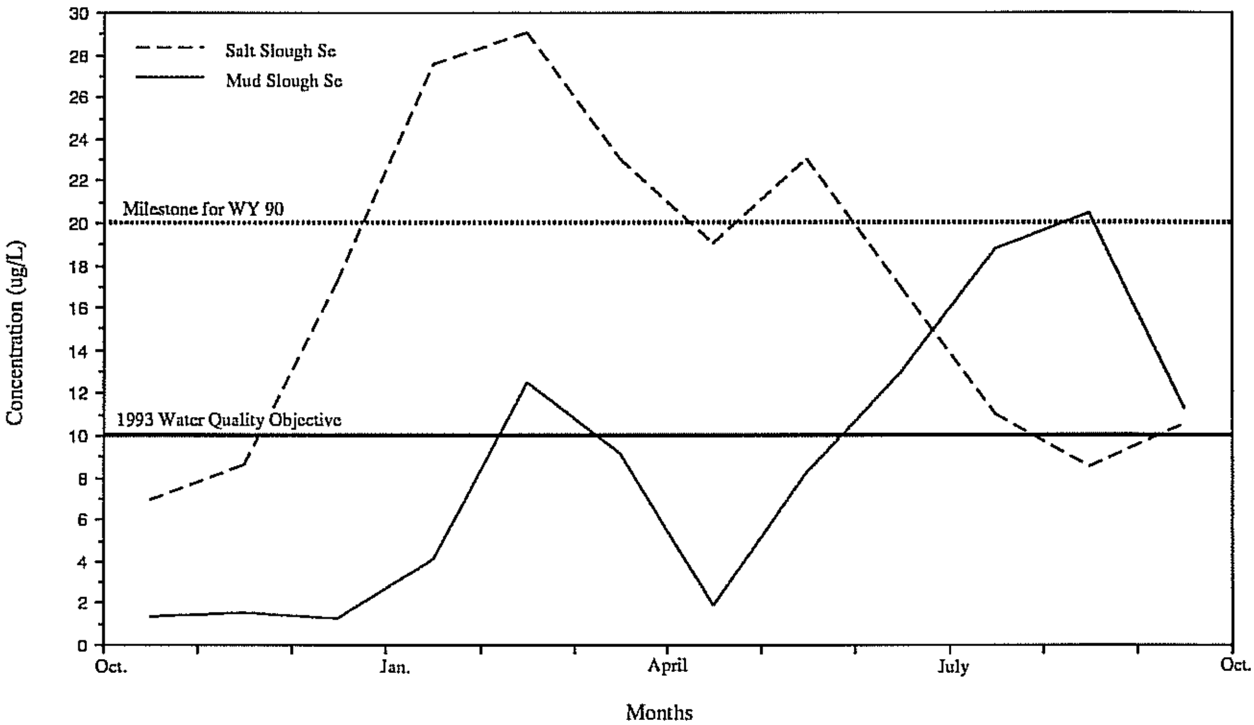
TIME PERIOD	MUD SLOUGH (NORTH) SALT SLOUGH
WY 90 (10/89 - 9/90)	20 μg/L
WY 91 (10/90 - 9/91)	17 μg/L
WY 92 (10/91 - 9/92)	15 μg/L

Although both sloughs exceeded the 1993 selenium water quality objective (10 μg/L) during WY 90, only Salt Slough consistently exceeded the WY 90 selenium milestone of 20 μg/L (Figure 9). Monthly mean selenium concentrations reached a maximum (29 μg/L) in February 1990 and stayed above 20 μg/L from January to June 1990. Mud Slough reached its maximum monthly mean selenium concentration in September 1990 as it just reached the WY 90 milestone of 20 μg/L.

The 1993 selenium water quality objective (10 μg/L) was exceed by Salt Slough during all but three months in WY 90. The 1993 objective was exceeded in Mud Slough during five months in WY 90. The 1993 maximum selenium concentration objective (26 μg/L) was exceeded twice during the early summer in Mud Slough (north) with concentrations reaching 28 μg/L. Salt Slough exceeded the maximum concentration on eight separate occasions. Most exceedences occurred during the non-irrigation season (January through March) with the highest value recorded on 2 February 1990 at 36 μg/L selenium.

Continuing drought conditions during WY 91 may increase the difficulties in meeting future milestones and objectives adopted and approved for both sloughs. The monthly mean concentrations of boron, molybdenum, and selenium will continue to be reviewed in future water years.

Figure 9. Mean Monthly Selenium Concentrations in Mud Slough (north) at Hwy. 140 and Salt Slough at Lander for WY 90, as Compared to the Adopted Water Quality Objective and Milestone Established to Measure Progress toward Meeting the Objective.



REFERENCES

Chilcott, J.E., D.W. Westcot, K.M. Werner, and K.K. Belden, 1988. Water Quality Survey of Tile Drainage Discharges in the San Joaquin River Basin. Agricultural Unit, Central Valley Regional Water Quality Control Board.

Chilcott, J.E., Westcot, D.W., Belden, K.K., and O'Connor K.A., 1989. Agricultural Drainage Contribution to Water Quality in the Grassland Area of Western Merced County, California: October 1987 through September 1988. Regional Water Quality Control Board, Central Valley Region Report, 44 pages.

Deverel, S.J., R.J. Gilliom, R. Fujii, J.A. Izbicki, and J.C. Fields, 1984. Areal Distribution of Selenium and Other Inorganic Constituents in Shallow Groundwater of the San Luis Drain Service Area, San Joaquin Valley, California: A Preliminary Study. U.S. Geological Survey Water Resource Investigation 84-4319, 67 p.

EPA. (U.S. Environmental Protection Agency) 1985. Water Quality Criteria. Federal Register, v.50, n.145. Washington D.C.

James, E.W., Westcot, D.W., Grewell, B.J., Belden, K.K., Boyd, T.F., Waters, R.I., and Thomasson, R.R., 1988. Agricultural Drainage Contribution to Water Quality in the Grassland Area of Western Merced County, California. Central Valley Regional Water Quality Control Board Report, 169 pages.

Lowry, P.A., R.J. Schnagl, and J.L. Gonzalez, 1989. Ground Water Quality in the South Grassland Area of the Western San Joaquin Valley, California. Agricultural Unit, Central Valley Regional Water Quality Control Board.

Marshack, J.B., 1988, personal communication. Central Valley Regional Water Quality Control Board, 3443 Routier Road, Sacramento, CA 95827.

Pierson, F. W., E.W. James, and R.R, Thomasson, 1988a. Hydrology Study of Mud Slough (North), Merced County. Agricultural Unit, Central Valley Regional Water Quality Control Board.

Pierson, F.W, E.W. James, and R.R. Thomasson, 1988b. Hydrology Study of Salt Slough, Merced County. Agricultural Unit, Central Valley Regional Water Quality Control Board.

Westcot, D.W., Chilcott, J.E., Enos, C.A. and Rashmawi, E.A., 1990. Agricultural Drainage Contribution to Water Quality in the Grassland Area of Western Merced County, California: October 1988 through September 1989 (Water Year 1989). Regional Water Quality Control Board, Central Valley Region Report.

JUSTIFICATION FOR THE CURRENT GUIDELINES FOR SELENIUM CONTENT OF DRINKING WATER FOR ANIMALS

For man, the recommended maximum allowable concentration for a safe level of selenium in the drinking water in the United States has changed somewhat over the past half century. For instance, the U. S. Public Health Service recommendations have changed as follows (McKee and Wolf 1963, p.91):

Year	Recommended Standard
1925	None established
1942	50 μg Se/L
1946	50 μg Se/L
1962	10 μg Se/L

At present, the recommendation is still 10 μg Se/L, as recommended by the EPA Committee on Water Quality Criteria (NAS-EPA 1972, pp.304-22). The WHO International standard for selenium in drinking water for man was 50 μg Se/L for 1958 and for 1961. There seems to be no compelling data that would direct the adoption of more restrictive guidelines for man.

The 1972 NAS-EPA guidelines for levels of selenium in animal drinking water state that 0.05 mg/L is the maximum acceptable concentration. In reviewing the literature relative to selenium toxicity, it would appear that much of the data support the assumption that no observable signs of toxicity will be produced by up to 1 ppm in the feed. Translating selenium intake from this dietary level into a drinking water concentration that will give an equivalent intake is complicated by several factors. These include the estimation of an average feed consumption and water intake. The water intake, in turn, varies greatly depending on the animal species, ambient temperature, quality of water and type and amount of feed intake. The calculations and estimations which follow, are based on a "worst case" scenario.

Of major concern in establishing drinking water guidelines is the water intake of the animals. The intake may be greater than the requirement and it may be greatly influenced by temperature, lactation, salt content of the water, etc. Church and Pond (1988) make the generalization that animals will consume 3-4 grams water for every gram of dry feed when they are not heat stressed. Species with the capability to conserve water, such as sheep, will require less while cattle will probably require the most. Birds generally require less water than mammals and young animals will usually require more water per unit of body weight than adults. It appears that animal nutritionists commonly assume a ratio of water to feed intake of about 3:1.

APPENDIX A

Mineral and Trace Element Water Quality Data for Inflow Monitoring Stations
Listed in Order by Map Index Number

Map Index	RWQCB Site I.D.	Site Name	Page
I-1	MER556	Main (Firebaugh) @ Russell Avenue	25
I-2	MER501	Panoche Drain	26
I-3	MER552	Agatha Inlet (Mercy Springs) Drain	27
I-4	MER506	Agatha Canal	28
I-6	MER504	Hamburg Drain	29
I-7	MER505	Camp 13 Slough	30
I-8	MER502	Charleston Drain	31
I-9	MER555	Almond Drive Drain	32
I-10	MER509	Rice Drain	33
I-11	MER521	Boundary Drain	34
I-12	MER528	Salt Slough Ditch @ Hereford Road	35

The data presented in Tables 1-1 and 1-2 show that considerably higher water consumption can occur, particularly with cattle. This is an important factor in considering what the maximum allowable selenium content in water should be.

The data of Winchester and Morris (1956) (also shown in Tables 1-1 & 1-2) were used to calculate water to feed intake ratios for certain dairy and beef cattle at two different temperatures. These calculations are shown in Table 2-6. The data show that at 4°C, the water consumption was such as to give a water to feed

Table 2-6 Ratios of water to feed intakes for cattle calculated from data of Winchester and Morris (1956)

Class of Cattle	Kg water:Kg feed	
	4°C	32°C
Dairy cattle		
Heifers	3.00	7.35
Bulls	3.08	7.34
Non-lactating cows	3.09	7.34
Beef cattle		
On maintenance diet	3.09	7.34
Bulls	3.09	7.33
Cows on hay and/or grain		6.42
Cows on high-salt diet		9.22

ratio of about 3:1. However, at 32°C the water to feed ratio was almost 7.5:1. No doubt this temperature represents a high heat stress, since the animals were held at a constant temperature which would be much higher than the average daily temperature they would be exposed to in areas such as the San Joaquin Valley. It does represent the extreme in water intake by animals.

It is reasonable to assume that animals would be able to safely consume the same amount of selenium in drinking water that is allowed to be added to feed. The FDA currently has approved the addition of 0.3 ppm selenium to feeds as inorganic selenium (FDA, 1987). Assuming the extreme water to feed intake ratio of 7.5:1, water containing a concentration of 0.040 µg/mL (0.3 divided by 7.5) would provide the same selenium intake as 0.3 ppm added to feed.

Map Index I-1. Main (Firebaugh) Drain at Russell Avenue (MER556)

Location: Latitude 36° 55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S., R.12E. E side of Russell Avenue., 2.7 mi. S of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo	Cu	Cr	Ni	Pb	Zn	B mg/L	Cl	SO4	HDNS	Temp. F°
10/6/89	1140	6.4	3730	52	38	6	10	14	<5	12	5.4	310	1300	690	65
10/30/89	1110	8.5	3190	41	34	7	8	8	<5	9	4.5	330	1000	610	61
11/30/89	1010	7.9	3150	49	16	5	13	11	<5	12	3.2	330	830	600	47
12/29/89	1055	7.0	5360	107	26	2	7	<5	<5	6	5.3	780	1800	1200	46
1/19/90	825	8.2	3400	50	15	3	8	10	<5	13	3.0	445	955	720	44
2/2/90	810	8.1	3310	62	13	4	14	11	<5	17	3.1	330	840	720	46
3/30/90	740	8.1	3090	51	25	4	10	11	<5	8	4.1	450	1000	670	59
4/12/90	850	7.8	4240	75	26		15				4.8				64
4/27/90	835	7.9	4160	75		26	46	31	<5	40	4.6	450	1400	950	63
5/31/90		8.4	8780	9	63	1	4	11	<5	9	23	980	3400	1800	69
6/28/90	745	9.1		63	16	12	31	28	<5	44	4.6	370	1200	740	69
7/27/90	1150	7.9	3100	64	13	11	29	30	<5	41	4.5	330	1100	670	83
8/30/90	1545	8.0	3660	76	23	5	11	15	<5	26	5.4	370	1500	820	75
9/28/90		8.0		4	24	2	6	14	<5	14	20	810	2200	1400	68
MIN		6.4	3090	9	13	2	7	<5	<5	6	3.0	310	830	600	44
MED		8.0	3400	52	24	5	10	11	<5	13	4.6	370	1200	720	63
MAX		9.1	8780	107	63	26	46	31	<5	44	23	980	3400	1800	83
COUNT		14	12	14	13	13	14	13	13	13	14	13	13	13	14

Map Index I-2. Panoche Drain at O'Banion Gauge Station (MER501)

Location: Latitude 36°55'27", Longitude 120°41'19". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T. 11S., R.12E.
Located 0.5 mi. S of CCID Main Canal, 1.9 mi. W of Russell Rd., 5.5 mi. SW of Dos Palos,
3.4 SW of South Dos Palos.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	HDNS	Temp.
			µmhos/cm	µg/L							mg/L				F°
10/6/89	1210	8.1	5760	152	12	5	16	10	<5	10	9.7	660	1700	1300	66
11/6/89	1120	7.0	4750	82	8	3	29	9	<5	9	7.8	670	1300	1100	58
11/30/89	935	7.6	4150	69	8	4	27	8	<5	10	6.1	510	9900	1100	48
12/29/89	1218	7.6	4350	106	5	8	50	19	<5	34	6.2	590	1300	1100	50
1/25/90	910	7.5	2820	121	4	8	55	17	<5	31	6.1	670	1600	1200	50
3/30/90	755	8.0	4150	50	5	4	44	18	<5	12	7.0	770	1100	980	56
4/12/90	840	7.8	4350	49	6		35				7.2				62
4/27/90	850	8.0	4830	63	7	16	48	7	<5	15	7.7	700	1400	1200	63
5/31/90	1335	8.1	4770	63	8	1	46	6	<5	7	7.8	670	1400	1200	69
6/28/90	710	8.8		30	6	4	35	11	<5	15	7.4	565	1150	1000	64
7/27/90	1120	8.1	3630	31	6	2	19	7	<5	6	6.8	460	1100	890	83
8/30/90	1600	8.5	5330	76	11	2	15	7	<5	10	7.5	600	1400	1100	82
9/28/90		7.5		118	12	1	11	<5	<5	6	9.0	700	1700	1200	69
MIN		7.0	2820	30	4	1	11	6	<5	6	6.1	460	1100	890	48
MED		8.0	4550	72	8	4	32	9	<5	10	7.5	665	1400	1100	64
MAX		8.8	5760	152	12	16	55	19	<5	34	9.7	770	9900	1300	83
COUNT		13	11	13	13	12	13	12	12	12	13	12	12	12	13

Map Index I-3. Agatha Inlet (Mercy Springs) Drain near Panoche Drain (MER552)

Location: Latitude 36°56'01", Longitude 120°42'05". In SE 1/4, SE 1/4, NW 1/4, Sec. 31, T. 11S., R.12E. S of Firebaugh Drain, 2.6 mi. W of Russell Ave., 2.8 mi. S of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/6/89	1155	7.8	8200	5.1		20	1200	2600	1600	74
10/30/89	1045	8.4	8550	4.6		22	1100	3000	510	
11/30/89	945	8.3	6730	8.8		16	640	2500	1600	40
3/30/90	810	8.6	5110	10	8	12	840	1600	1110	55
4/27/90	910	8.1	4130	7.9		7.1	520	1400	1000	67
5/31/90	1350	8.0	4710	54	10	7.9	640	1400	1200	69
6/28/90	725	8.9		6.5	9	8.4	620	1000	840	70
7/27/90	1130	8.0	3410	35		5.7	410	1100	810	82
8/30/90	1610	8.1	3350	5.1		6.5	540	1100	780	79
MIN		7.8	3350	4.6		5.7	410	1000	510	40
MED		8.1	4910	7.9		8.4	640	1400	1000	70
MAX		8.9	8550	54		22	1200	3000	1600	82
COUNT		9	8	9		9	9	9	9	8

Map Index I-4. Agatha Canal at Helm Canal (MER506)

Location: Latitude 36°56'04", Longitude 120°41'06". In NE 1/4, Se 1/4, NW 1/4, Sec. 31, T.11S., R.12E. 150 ft. N of Helm Canal, 2.6 mi. W of Russell Ave., 3.4 mi. SW of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/6/89	1124	5.8	430	1.7		0.07	54	29	86	68
10/30/89	1015	8.5	840	1.8		0.82	120	140	220	63
11/30/89	900	7.8	4040	56		5.6	480	950	900	46
4/27/90	815	7.9	4470	60		6.6	570	1300	1000	63
5/31/90	1315	7.9	3300	23	8	5.0	460	840	770	66
6/28/90	650	8.8	4690	23	7	8.0	620	1100	970	67
7/27/90	1100	7.9	3470	26	9	6.6	450	1100	810	81
8/30/90	1530	8.3	4150	61	8	7.2	600	1400	1100	78
9/28/90		7.7	5280	114	11	9.6	760	1800	1300	68
MIN		5.8	430	1.7	7	0.07	54	29	86	46
MED		7.9	4040	26	8	6.6	480	1100	900	67
MAX		8.8	5280	114	11	9.6	760	1800	1300	81
COUNT		9	9	9	5	9	9	9	9	9

Map Index I-6. Hamburg Drain near Camp 13 Slough (MER504)

Location: Latitude 36°56'32", Longitude 120°45'23". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E.
50 ft. S of CCID main Canal, 9.2 mi. S-SE of Los Banos, 6.7 mi. W-SW of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se	Mo	Cu	Cr µg/L	Ni	Pb	Zn	B	Cl	SO4 mg/L	HDNS	Temp. F°
10/30/89	940	8.6	3900	39	6	<1	4	<5	<5	2	4.7	390	1400	1400	59
11/30/89	840	7.9	3060	26	5	<1	4	<5	<5	<1	2.1	290	1100	1200	48
1/19/90	720	8.3	5110	88	6	<1	16	<5	<5	4	5.4	810	1600	1800	46
2/2/90	730	7.7	5880	118	5	<1	13	<5	<5	6	5.7	720	1650	1700	48
3/30/90	700	7.8	4740	84	2	9	44	20	<5	31	5.0	890	1400	700	56
4/12/90	755	7.7	5850	105	4		21				5.3				58
4/27/90	750	7.8	5970	96	6	19	21	<5	<5	7	6.2	780	1900	1900	61
5/31/90	150	8.1	5770	122	5	9	23	28	15	79	5.9	800	1850	1900	89
6/28/90	630	8.8	4090	51	3	6	20	14	<5	24	4.0	490	1100	1000	62
7/27/90	1035	7.9	4190	56	8	1	10	<5	<5	5	5.5	540	1400	1200	78
8/30/90	1505	8.3	5200	90	5	<1	14	6	<5	10	6.5	790	1900	1700	78
9/28/90		7.7	3180	29	6	2	3	<5	<5	2	3.9	305	1050	1100	66
MIN		7.7	3060	26	2	<1	3	<5	<5	<1	2.1	290	1050	700	46
MED		7.9	4740	84	5	1	14	<5	<5	6	5.4	720	1400	1400	61
MAX		8.8	5970	122	8	19	44	28	15	79	6.5	890	1900	1900	89
COUNT		12	12	12	12	11	12	11	11	11	12	11	11	11	12

Map Index I-7. Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36°56'04", Longitude 120°41'06". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 ft. N of CCID Main Canal, 6.4 mi. W of Russell Ave., 9.2 mi. SE of Los Banos, 6.7 mi. SW of South Dos Palos.

Date	Time	pH	EC	Se	Mo	B	Cl	SO4	HDNS	Temp.
			µmhos/cm	µg/L		mg/L				F°
10/30/89	955	8.6	1980	19		2.5	220	440	780	59
11/30/89	845	8.3	740	1.8	1	0.22	120	62	120	49
12/29/89	940	7.6	4390	84	9	5.8	560	1300	1000	46
1/19/90	725	8.2	3410	67		4.1	490	920	870	44
2/2/90	740	8.1	3460	65	5	3.9	420	860	780	45
3/30/90	705	8.1	3200	39	7	4.9	560	860	730	57
4/12/90	745	7.9	3610	47	7	5.1				60
4/27/90	800	8.0	3160	46	8	3.2	370	900	670	64
5/31/90	1300	7.9	4640	57	13	5.6	560	1300	1100	66
6/28/90	640	8.8	3870	52	10	4.9	400	1100	760	69
7/27/90	1040	7.9	3270	51	20	5.1	340	1100	740	80
8/30/90	1513	8.3	5190	89	5	6.6	830	2100	1900	78
9/28/90		7.7	5160	96	34	8.9	650	1700	1100	66
MIN		7.6	740	1.8	1	0.22	120	62	120	44
MED		8.1	3440	54	9	4.9	455	1010	780	62
MAX		8.8	5190	96	34	8.9	830	2100	1900	80
COUNT		13	13	13	13	13	12	12	12	13

Map Index I-8. Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36°56'59", Longitude 121°46'55". In NE 1/4, SE 1/4, NE 1/4, Sec. 29, T.11S., R.11E.
N side of CCID Main Canal, 8.7 mi. S-SE of Los Banos, 7.9 mi. W-SW of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cu (µg/L)	Cr (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B (mg/L)	Cl (mg/L)	SO4 (mg/L)	HDNS (mg/L)	Temp. F°
10/30/89	925	7.9	4720	70	7	3	13	<5	<5	8	4.9	530	1600	680	62
11/30/89	700	7.8	4700	69	7	3	12	6	<5	8	4.4	520	1500	1500	48
12/29/89	917	7.6	2880	39	4	3	13	<5	<5	13	2.5	360	780	860	46
1/19/90	705	7.9	4800	68	7	3	14	8	<5	16	4.0	610	1700	1600	48
2/2/90	710	7.8	3010	41	2	7	18	14	<5	30	2.1	340	770	810	45
3/30/90	645	7.8	5410	112	7	2	14	8	<5	14	4.5	950	1800	1600	56
4/12/90	726	7.7	5210	111	5		19				4.9				60
4/27/90	740	7.7	5340	108	6	18	16	9	<5	19	4.1	660	1800	1700	63
5/31/90	1235	7.7	4000	72	4	8	21	38	<5	32	3.2	490	1300	1200	66
6/28/90	620	8.5	5120	95	7	1	8	6	<5	19	3.7	540	1700	1400	63
7/27/90	1020	7.9	2680	44	1	60	100	86	17	160	2.4	330	750	760	78
8/30/90	1455	8.0	3640	62	5	5	9	10	<5	18	3.6	540	1300	1100	77
9/28/90		7.7	2690	34	4	3	2	<5	<5	12	3.0	330	780	810	66
MIN		7.6	2680	34	1	1	2	6	<5	8	2.1	330	750	680	45
MED		7.8	4350	69	6	3	14	8	<5	17	3.7	525	1400	1150	63
MAX		8.5	5410	112	7	60	100	86	17	160	4.9	950	1800	1700	78
COUNT		13	13	13	13	12	13	12	12	12	13	12	12	12	13

Map Index I-9. Almond Drive Drain (MER555)

Location: Latitude 36° 59'55", Longitude 120°49'00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6, T11S., R.11E. N side of Almond Dr., 1.1 mi. E of Mercy Springs Drain, 100 ft. E of CCID Main Canal, 4.7 mi. S of Los Banos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/30/89	900	8.7	600	0.7		0.21	88	48	110	60
11/30/89	650	7.5	840	2.3		0.42	110	90	160	47
12/29/89	850	7.6	1010	2.2		0.70	160	190	220	42
1/19/90	645	8.3	1180	2.3	3	0.57	150	150	190	44
2/2/90	650	7.3	1150	3.2		0.71	140	180	240	49
3/30/90	630	7.7	2190	2.8	4	2.1	360	480	530	56
4/12/90	700	7.8	1710	2.7	2	1.5				58
4/27/90	720	7.8	1850	4.0		1.5	210	360	420	62
5/31/90	1130	7.7	2570	4.7	5	2.4	290	620	650	68
6/28/90	605	8.6	1480	2.4	2	1.1	160	250	300	68
7/27/90	1010	7.7	790	1.9		0.46	120	100	180	81
8/30/90	1440	8.0	1570	2.2		1.6	170	310	330	75
9/28/90		8.4	1450	1.6		1.4	150	250	310	66
MIN		7.3	600	0.7		0.21	88	48	110	42
MED		7.7	1320	2.3		0.91	155	220	270	61
MAX		8.7	2570	4.7		2.4	360	620	650	81
COUNT		13	13	13		13	12	12	12	13

Map Index I-10. Rice Drain at Mallard Road (MER509)

Location: Latitude 36°59'22", Longitude 120°14'42". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E. South of Santa Fe Grade at Brito, 50 ft. W of Mallard Rd., 4.5 mi. W of Dos Palos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/30/89	1145	8.2	3550	2.7	41	8.1	330	1100	740	61
11/30/89	1025	7.4	2970	1.9	19	5.1	300	780	800	48
12/29/89	1305	7.0	4020	36	38	7.4	440	1400	1100	48
1/19/90	835	8.1	3800	2.0	30	6.3	450	1200	1000	43
2/2/90	830	7.8	3080	3.3		5.3	290	840	740	46
3/30/90	840	7.7	3050	1.5	1	3.7	490	600	620	57
4/12/90	914	7.6	3000	2.5	15	6.2				64
4/27/90	935	7.2	2310	2.3	11	4.5	270	640	510	66
5/31/90		8.1	3020	2.5	16	5.4	390	870	750	70
6/28/90	755	8.9		3.7	16	6.3	370	870	670	69
7/27/90	1225	7.9	2400	2.6	11	4.5	290	620	500	84
8/30/90	1630	8.1	2350	3.0	12	4.5	300	660	520	75
9/28/90		7.8	4110	4.0	21	9.3	535	1300	845	68
MIN		7.0	2310	1.5	1	3.7	270	600	500	43
MED		7.9	3050	2.7	16	5.4	350	855	740	64
MAX		8.9	4110	36	41	9.3	535	1400	1100	84
COUNT		13	12	13	12	13	12	12	12	13

Map Index I-11. Boundary Drain at Department of Fish and Game Pump (MER521)

Location: Latitude 37°06'32", Longitude 120°46'45". In NE 1/4, SE 1/4, NE 1/4, Sec. 32, T.9S., R.11E. North of Henry Miller Rd., 4.6 mi. NE of Los Banos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/6/89	1300	7.8	1140	1.2		0.36	170	130	210	68
10/30/89	1044	6.6	1480	0.5		0.51	260	200	270	57
11/30/89	1115	7.8	1510	0.6		0.44	240	180	260	49
12/29/89	1430	7.4	2050	2.3		0.46	260	170	290	52
2/2/90	910	7.8	2440	2.0		0.96	380	350	450	48
3/30/90	915	7.5	2450	1.8	1	0.81	420	370	500	60
4/12/90	1020	7.4	1790	0.9	6	0.55				66
4/27/90	1010	7.5	1650	0.7		0.45	290	210	330	
5/31/90	1510	8.3	1520	0.9	5	0.44	260	230	770	70
6/28/90	830	9.0	1370	1.2	4	0.41	240	160	280	67
7/27/90	1330	8.8	970	0.5	3	0.31	170	110	210	81
8/31/90	700	8.0	1140	0.9		0.39	180	130	260	67
9/28/90		7.7	680	0.8		0.16	99	59	140	69
MIN		6.6	680	0.5		0.16	99	59	140	48
MED		7.8	1500	0.9		0.44	250	175	275	67
MAX		9.0	2450	2.3		1.0	420	370	770	81
COUNT		13	13	13		13	12	12	12	12

Map Index I-12. Salt Slough Ditch at Hereford Road (MER528)

Location: Latitude 37°08'30", Longitude 120°45'17". In NW 1/4, NE 1/4, NW 1/4, Sec. 22, T.9S., R.11E. 3.0 mi. N on Hereford Rd. from Henry Miller Rd.

Date	Time	pH	EC µhmos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	Total Alk. mg/L	HDNS mg/L	Temp. F°
10/6/89	1320	7.9	930	1.2		0.31	130	110				180	67
10/30/89	1100	7.2	940	0.4		0.26	140	100				200	58
11/30/89	1130	7.8	1030	1.2		0.23	140	99				220	49
12/29/89	1455	7.6	1250	0.2		0.33	190	160				280	48
1/19/90	930	7.9	1700	0.2		0.33	280	230				410	43
2/2/90	920	7.8	1350	1.4		0.35	190	150	<2	220	220	320	46
3/30/90	930	8.0	1050	2.3	4	0.43	200	160				230	59
4/12/90	1035	7.6	1780	0.6	11	0.43							66
4/27/90	1025	7.5	1480	0.6		0.33	240	180				370	68
5/31/90	1435	8.1	1170	0.9	4	0.30	180	150				290	68
6/28/90	850	8.8	970	0.5	5	0.24	160	97				220	69
7/27/90	1315	9.3	680	0.6		0.22	120	63				150	80
8/31/90	720	8.0	800	0.9		0.24	140	100				410	69
9/28/90		7.6	780	0.6		0.15	130	83				190	69
MIN		7.2	680	0.2		0.15	120	63				150	43
MED		7.9	1030	0.6		0.30	160	110				230	67
MAX		9.3	1700	2.3		0.43	280	230				410	80
COUNT		14	14	14		14	13	13				13	14

Another way of looking at the same problem is to calculate the selenium intake from the maximum expected water consumption for various adult livestock of medium weight at a temperate climate. The results of these calculations are shown in Table 2-7. The calculations are made on the basis of assumed body weights of various animals and on the assumption that animals consume feed at an average of 2.5% of body weight. Since the maximum value for expected water consumption is used, these calculations also approximate a "worst case" situation. The fifth column of Table 2-7 gives the selenium intake from the water, assuming it contains the currently accepted maximum selenium concentration of 0.05 μg/mL. Dividing this value by the estimated feed intake for each animal gives the concentration of selenium in the diet that would provide an equivalent daily intake (shown in the last column). These values can vary from 0.18 μg Se/g diet to 0.49 μg Se/g diet, with an overall average of 0.35 ± 0.13. This agrees quite well with the calculated dietary level from the other worst case study involving heat stressed animals.

Table 2-8 presents a summary of the comparative calculations of selenium intakes from situations of various selenium concentrations in feeds and water. At the extreme water to feed ratio of 7.5:1, the amount of selenium intake by animals drinking water containing the maximum accepted selenium concentration would be equivalent to consuming a level of 0.375 ppm selenium in the diet. This is slightly above the level that has been approved for supplementation (0.3 ppm). However, it is still one half of the level considered to give no observable toxicity signs and it is one tenth of the level considered to produce toxicity. Choosing a water to feed ratio of 7.5:1 is certainly a worst case situation, since animals would rarely be at a temperature of 32°C for long periods of time. The level of intake from water under these extreme conditions is very close the that provided by the approved supplementation of the diet with 0.3 ppm. Therefore, the current guideline of 0.050 μg/mL in animal drinking water seems to be justified and probably represent a conservative and rational limit.

In support of this conclusion is the observation that animals consuming water at this level would consume the amount of selenium equivalent to that supplied by 0.375 ppm in the diet. If it is assumed the diet contains 0.4 ppm natural selenium, in addition to the permitted 0.3 ppm supplemental selenium, the total selenium intake would be equivalent to that from a dietary concentration of 1.08 ppm. This is close to the level of no effect. The average selenium content of the feeds in the San Joaquin Valley are usually less than 0.4 ppm used in the above calculation (Kubota et al. 1967; Burau et al. 1987).

APPENDIX B

Mineral and Trace Element Water Quality Data for Internal Flow Monitoring Stations
Listed in Order by Map Index Number

Table 2-7 Daily Se intake calculated from maximum expected intake of water containing the accepted limit of 0.05 ug Se/mL

Animal	Typical body wt. Kg	Feed consumed (2.5% body wt) Kg	Maximum expected water intake[a] L/day	Se intake from water containg 0.05 mg/mL mg	Dietary Se content to provide equivalent Se intake as in water mg/Kg
Beef cattle	363	9.1	72	3.6	0.40
Dairy cattle	450	11.3	110	5.5	0.49
Swine	113	2.82	19	0.95	0.39
Horses	454	11.4	45	2.25	0.20
Chickens	2.3	0.058	0.4	0.020	0.34
Turkeys	6.8	0.17	0.6	0.30	0.18
				Average ± SD	0.35 ± .12

[a]Taken from NAS-NRC 1974

Map Index T-1. CCID Main Canal at Russell Avenue (MER510)

Location: Latitude 36°55'28", Longitude 120°37'30". In SE 1/4, SE 1/4 SE 1/4, Sec. 33, T.11S., R.12E. 2.7 mi. S of Dos Palos.

Date	Time	pH	EC	Se	Mo	B	Cl	SO4	HDNS	Temp.
			μmhos/cm	μg/L		mg/L				F°
10/6/89	1135	6.4	470	1.1		0.10	65	37	89	66
10/30/89	1125	8.6	620	0.8		0.21	91	53	220	62
11/30/89	1000	8.3	660	1.4		0.18	98	55	470	51
12/29/89	1105	7.8	770	2.7		0.34	130	93	140	45
1/19/90	825	8.8	830	2.3		0.37	130	120	160	44
2/2/90	815	8.5	880	4.0		0.38	120	100	180	45
3/30/90	730	8.1	650	2.5	1	0.32	100	100	150	61
4/12/90	855	8.6	595	1.7	1	0.16				64
4/27/90	825	8.2	680	1.6		0.16	130	49	130	66
5/31/90		7.9	4280	76	25	5.2	460	1400	1100	69
6/28/90	740	9.4	670	1.2	1	0.26	110	77	150	67
7/27/90	1145	7.8	2330	4.9		5.1	240	710	450	83
8/30/90	1540	8.3	460	0.7		0.16	65	48	130	78
9/28/90		7.7	2610	3.8	19	3.9	260	830	520	68
MIN		6.4	460	0.7		0.10	65	37	89	44
MED		8.2	680	2.3		0.32	120	93	160	66
MAX		9.4	4280	76		5.2	460	1400	1100	83
COUNT		14	14	14		14	13	13	13	14

Map Index T-7. San Luis Canal at HWY 152 (MER527)

Location: Latitude 36°03'03", Longitude 120°48'10".
In SE 1/4, SW 1/4, SE 1/4 Sec. 18, T.10S., R.11E.
N side of HWY 152, 2.5 mi. E of Los Banos.

Date	Time	pH	EC µhmos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/30/89	1205	8.6	670	0.7	6	0.38	90	64	190	64
11/30/89	1040	8.1	910	1.5		0.55	120	110	160	50
12/29/89	1328	7.8	1370	2.0		1.8	180	270	280	46
1/19/90	850	8.1	1430	2.5		1.5	180	270	340	44
2/2/90	850	8.3	950	3.4		0.56	130	130	200	47
3/30/90	900	8.1	820	2.4	3	0.56	96	110	180	56
4/12/90	945	7.7	2350	2.7	6	2.7				62
4/27/90	950	7.9	2460	2.7		3.1	300	570	600	66
5/31/90	1500	8.1	3280	3.9	6	4.5	450	880	810	75
6/28/90	815	8.9	1990	2.7	5	2.5	230	450	450	70
7/27/90	1300	7.9	1860	2.2		2.2	210	400	410	84
8/30/90	1700	8.5	2020	2.7		2.6	230	460	450	79
9/28/90		8.0	620	1.4		0.34	78	64	130	69
MIN		7.8	620	0.7		0.38	90	64	160	44
MED		8.1	1400	2.5		1.7	180	270	310	65
MAX		8.9	3280	3.9		4.5	450	880	810	84
COUNT		13	13	13		13	12	12	12	13

APPENDIX C

Mineral and Trace Element Water Quality Data for Outflow Monitoring Stations
Listed in Order by Map Index Number

Table 1-1 Continued

Animal	Comments		Water intake*	Reference
Swine	Growing			
	23 kg	Fall	2.1	Merck 1961, p737
		Spring	2.6	" " "
	45 kg	Fall	3.6	" " "
		Spring	4.2	" " "
	68 kg	Fall	4.2	" " "
		Spring	4.7	" " "
	91 kg	Fall	4.5	" " "
		Spring	4.2	" " "
	136 kg	Fall	2.8	" " "
		Spring	2.8	" " "
	Adult		11-19	FWPCA 1968, p130
	Growing, 30 kg		6	NAS-NRC 1974, p31
	Fattening, 60-100 kg		8	" " " "
	Lactating sows, 200-250kg		14	" " " "
Poultry	Adult chickens		0.3-0.38	FWPCA 1968, p130
	Hens		0.14-0.18	Ewing 1963, p53
	Turkeys		0.38-0.57	FWPCA 1968, p130
	Turkeys	1-3 wk	0.042-0.095	Ewing 1963, p1109
		4-7 wk	0.14-0.32	" " "
		9-13 wk	0.35-0.54	" " "
		15-19 wk	0.63	" " "
		21-26 wk	0.51-0.64	" " "
	Chicken, 8-wk old		0.2	NAS-NRC 1974, p31
	Laying hen, 60% production		0.2	" " " "

* Liters per animal per day.

Winchester and Morris (1956) reported a very thorough study of the water intake of cattle under a variety of conditions, and some of their data were used in calculating the values for Table 1-2. These values reflect "total water intake" (water drank plus water contained in the feed) rather than "water consumption" ("free water"drank) or "water requirement" (equivalent of water from all sources, including metabolic, required for good health). The data are summarized in some detail since they provide information concerning the effects of so many factors.

Winchester and Morris (1956) have also shown the water intake of lactating dairy cattle to increase as the milk production increases.

Map Index O-1. Mud Slough at Newman Land and Cattle Company (MER551)

Location: Latitude 37°18'33", Longitude 120°57'18". In NW 1/4, NW 1/4, SW 1/4, Sec. 23, T.7S., R.9E., 1.7 mi. NE of Santa Fe Grade, 1.2 mi. N of HWY 140, 4.2 mi. NE of Gustine.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/30/89	1245	7.7	1030	0.6		0.61	150	120	240	59
11/30/89	1135	7.0	1560	2.8		1.1	190	210	310	51
12/29/89	1035	8.0	2080	0.9		1.3	310	370	360	41
1/19/90	1245		2480	5.0		1.7	360	480	490	49
2/2/90	1315	7.4	3070	5.7		2.2	470	580	520	51
3/30/90	1355		4040	4.5	17	3.2	600	920	740	70
4/12/90	1310	8.4	4330	2.1	16	2.9				66
4/27/90	1210	8.6	3360	1.2	9	2.8	520	540	600	73
5/31/90	1245	8.2	2860	8.1	10	2.4	400	725	650	68
6/28/90	1040	9.6		2.5	9	1.7	330	595	580	74
7/27/90	1100	9.2	2160	6.8		2.5	280	480	370	80
8/31/90	845	8.5	1850	5.3	11	1.6	210	400	450	66
9/14/90	1230	8.8		2.5	10	2.3				74
9/21/90	820	8.1		4.3	5	2.5				63
9/28/90	1015		2560	4.4	9	2.0	340	620	570	69
MIN		7.0	1030	0.6	5	0.61	150	120	240	41
MED		8.2	2480	4.3	10	2.1	335	510	505	67
MAX		9.6	4040	8.1	17	3.2	600	920	740	80
COUNT		12	12	15	9	15	12	12	12	15

Map Index O-2. Mud Slough (North) at HWY 140 (MER541)

Location: Latitude 37°17'28", Longitude 120°56'34". In NW 1/4, SE 1/4, SE 1/4, Sec. 26, T.7S., R.9E. 1.7 mi. NE of the Santa Fe Grade HWY 140 intersection.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	HDNS	Temp.
			µmhos/cm	µg/L							mg/L				F°
10/6/89	1415	7.8	1460	1.9	6						0.92	180	240	260	70
10/13/89	1135	7.5	1920	1.2	11						1.1	220	320	330	66
10/20/89	1225	5.9	1120	1.0	6						0.77	160	150	210	68
10/30/89	1205	7.6	990	1.0	5	3	5	7	<5	4	0.60	130	94	210	58
11/6/89	1300	7.7	1450	1.7	6										59
11/13/89	1130	6.9	1410	1.1	5	3	8	7	<5	10	0.87	190	200	240	58
11/20/89	945	7.4	1410	1.4	6	3	6	6	<5	7	0.93	220	220	260	53
11/30/89	1220	7.7	1530	1.9	6	6	5	6	<5	7	1.1	200	210	220	50
12/8/89	1100	7.3	1865	1.4	7	2	4	6	<5	6	1.2	270	300	340	48
12/15/89	1105	8.3	1940	1.1	7	3	6	9	<5	10	1.2	285	300	300	43
12/21/89	950	7.6	1680	1.1							1.1	240	240	280	43
12/29/89	1200	8.1	2110	1.4	8	2	4	6	<5	6	1.4	340	380	360	42
1/5/90	1030	7.8	2620	1.4	11	2	4	<5	<5	6	1.7	360	470	440	42
1/11/90	1045	8.0	2540	0.9	9	2	7	8	<5	11	1.7	380	450	450	45
1/19/90	1200		2510	7.0	10	1	4	7	<5	6	2.0	390	520	490	48
1/26/90	1015	8.0		7.2	11						2.3	480	620	600	48
2/2/90	1230	8.1	3080	5.5	12	2	8	9	<5	8	2.2	450	600	540	50
2/19/90	1520	8.3		20	13	2	7	9	<5	5	3.4	480	710	620	49
2/26/90	1230		3030	12	12						3.1	410	610	600	
3/5/90	1300	8.0	3230	14	14						3.0	470	700	610	
3/9/90	1310	8.0	3600	12	18						3.1	530	720	680	59
3/16/90	1240	8.1	4120	11	20	3	13	12	<5	13	3.6	580	860	740	64
3/23/90	1210	7.2	4380	3.8	19						3.4	640	830	780	67
3/30/90	1045	8.2	5330	4.7	25	1	8	23	<5	5	4.1	770	1300	940	63
4/6/90	1245	7.9	5560	2.8	25						3.8				69
4/12/90	1148	8.1	6330	3.1	32	7					4.5				70
4/20/90	1040	8.2	4430	1.7	17						4.1				67
4/27/90	1130	8.5	3440	1.3	10	9	10	15	<5	13	3.0	520	580	540	68
5/4/90	1130	8.3	5420	1.6	19						3.8				84
5/11/90	1020	8.3	7560	1.4	25						5.3				68
5/18/90	1210	8.4	8940	1.1	29						5.8				70
5/25/90	1000	8.6	5220	8.7	19						3.8				65

Map Index O-2 continued. Mud Slough (North) at HWY 140 (MER541)

Location: Latitude 37°17'28", Longitude 120°56'34". In NW 1/4, SE 1/4, SE 1/4, Sec. 26, T.7S., R.9E. 1.7 mi. NE of the Santa Fe Grade HWY 140 intersection.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	HDNS	Temp.
			µmhos/cm	µg/L							mg/L				F°
5/31/90	1325	8.4	3730	28	22	2	5	5	4	7	4.0	560	1100	780	70
6/8/90	745	8.2	5540	3.7	20						4.2				70
6/15/90	1040	8.4	4580	28	19						5.6				68
6/22/90	1100	8.2	1980	4.9	8						1.7				74
6/28/90	1000	9.3		15	17	2	4	8	<5	6	4.9	510	980	740	70
7/6/90	1000	9.4	3470	22	16						4.8				77
7/13/90	855	9.4	4520	13	19						5.5				78
7/20/90	1012	9.5	3310	20	15						4.7				78
7/27/90	1145	9.5	3170	20	15	2	10	7	<5	11	5.0	420	890	710	80
8/3/90	955	9.5	1650	21	17						4.4				75
8/9/90	1115	8.2	2900	15	14						4.0				86
8/16/90	1045	9.9	3150	23	12						4.2				74
8/24/90	1050	8.7	3000	17	11						3.7				72
8/31/90	815	9.0	3040	26	10	3	7	9	<5	11	4.0	410	870	670	68
9/2/90	1240	8.1	3000	1.9	12						2.0	440	630	500	51
9/7/90	1005	8.2	3450	31	10						4.7	480	990	810	67
9/14/90	1045	9.0	3760	10	14						4.9				68
9/21/90	750	8.4	2770	7.8	9						3.2				67
9/28/90	1055		1160	5.1	9	3	5	9	<5	7	0.99	150	190	230	69
MIN		5.9	990	0.9	5	1	4	<5	<5	4	0.60	130	94	210	42
MED		8.2	3060	5.1	12	2	6	8	<5	7	3.4	410	590	520	67
MAX		9.9	8940	31	29	9	13	23	4	13	5.8	770	1300	940	86
COUNT		48	48	51	50	20	21	20	20	20	50	31	31	31	49

Map Index O-3. Los Banos Creek at HWY 140 (MER554)

Location: Latitude 37° 16'35", Longitude 120°57'14". In NE 1/4, SW 1/4, SW 1/4, Sec. 35, T.7S., R.9E. S side of HWY 140, 2.9 mi. NE of Gustine.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
10/30/89	1220	7.6	780	0.5		0.35	110	68	170	59
11/30/89	1210	7.3	1240	1.0		0.85	162	120	270	51
12/29/89	1145	8.3	4060	0.4		2.4	570	870	700	46
1/19/90	1215		2180	0.5		1.6	350	390	400	48
2/2/90	1245	8.1	2350	0.7		1.7	340	360	410	51
3/30/90	1050	7.9	2270	1.4	14	1.7	400	420	460	66
4/12/90	1200	7.9	2140	0.9	10	1.5				73
4/27/90	1140	8.4	3600	0.8	11	3.0	520	530	680	71
5/31/90	1315	8.3	1570	0.8		1.2	210	220	340	74
6/28/90	1010	9.4		0.5	20	1.2	180	290	330	69
7/27/90	1135	9.3	1210	1.3		1.0	150	210	280	79
8/31/90	820	8.3	1410	2.0		1.1	170	230	300	66
MIN		7.3	780	0.4		0.35	110	68	170	46
MED		8.3	1870	0.8		1.2	210	290	340	66
MAX		9.4	4060	2.0		3.0	570	870	700	79
COUNT		11	11	12		12	11	11	11	12

Map Index O-4. Salt Slough at Lander Avenue (HWY 165) (MER531)

Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E. 13.0 mi. N of Los Banos, 5.0 mi. S of HWY 140.

Date	Time	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cu (µg/L)	Cr (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B (mg/L)	Cl (mg/L)	SO4 (mg/L)	HDNS (mg/L)	Temp. F°
10/6/89	1345	7.6	1580	8.7	5						1.3	200	290	310	68
10/13/89	1200	7.7	1440	5.4	5						1.1	180	230	270	66
10/20/89	1255	7.0	1590	9.2	6						1.5	230	300	320	66
10/30/89	1125	7.4	1580	4.2	6	4	7	8	<5	9	1.3	220	260	320	58
11/6/89	1225	7.4	1690	9.4	5						1.4	240	320	360	58
11/13/89	1240	7.4	1670	7.2	6	4	8	7	<5	13	1.2	230	300	440	59
11/20/89	1015	7.4	1930	9.9	7	3	8	8	<5	18	1.7	260	360	360	54
11/30/89	1200	7.6	1810	7.7	6	10	6	5	<5	14	1.5	230	300	130	51
12/8/89	1130	7.7	2080	7.2	29	3	6	<5	<5	9	1.7	320	410	440	49
12/15/89	1215	8.0	2110	11	8	3	6	7	<5	11					45
12/21/89	900	7.0	2600	17							2.1	370	540	510	44
12/29/89	1245	7.8	2680	24	10	1	4	<5	<5	6	2.4	380	600	530	44
1/5/90	1115	7.8	2810	22	10						2.3	360	630	640	42
1/11/90	1115	8.0	3060	26	12	3	10	6	<5	12	3.0	470	790	730	45
1/19/90	1000		2960	27	9	4	11	11	<5	17	2.9	450	765	655	48
1/26/90	910	7.8	4050	35	10						3.1	520	820	720	50
2/2/90	1145	6.4	2970	36		3	13	12	<5	15	2.9	390	690	640	50
2/19/90	1445	8.1	2500	30	7	2	12	9	<5	12	2.6	360	610	550	49
2/26/90	1145	7.7	2460	21	8						2.5	320	560	580	
3/5/90	1230	7.9	2330	19	8						2.1	340	510	520	
3/9/90	1220	7.4	2840	29	11						2.6	380	600	660	59
3/16/90	1328	8.0	2820	24	10	4	15	10	<5	13	3.1	370	620	660	62
3/23/90	1305	7.1	2530	18	9						2.2	350	490	560	68
3/30/90	1000	7.8	3000	23	10	2	11	12	<5	9	3.1	590	720	660	62
4/6/90	1155	7.9	3000	24	9						2.6				66
4/12/90	1107	7.7	2650	16	8	13					2.2				68
4/20/90	1140	7.7	2340	14	7						2.4				66
4/27/90	1050	7.8	2730	20	8	11	13	12	<5	17	2.6	380	610	1000	70
5/4/90	1210	7.9	2680	28	7						2.7				76
5/11/90	1100	8.0	2710	31	8						2.8				70
5/18/90	1140	8.0	2850	25	9						3.0				68
5/25/90	920	7.2	2020	14	5						1.6				62
5/31/90	1400	8.1	2320	16	7	5	11	9	<5	16	2.3	340	550	550	68
6/8/90	815	7.9	2930	21	11						3.3				74
6/15/90	1000	7.3	2780	18	11						3.4				68
6/22/90	1010	7.1	2820	19	12						3.7				76
6/28/90	915	8.8	2090	11	8	7	16	16	<5	28	2.3	295	470	455	74
7/6/90	1045	9.4	1960	12	6						2.2				77

Map Index O-4 continued. Salt Slough at Lander Avenue (HWY 165) (MER531)

Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E. 13.0 mi. N of Los Banos, 5.0 mi. S of HWY 140.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cu µg/L	Cr µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L	Temp. F°
7/13/90	927	9.1	2410	13	8						3.0				82
7/20/90	935	8.9	1750	8.2	5						1.8				80
7/27/90	1235	9.9	1860	10	6	5	10	14	<5	25	2.0	250	410	420	78
8/3/90	915	9.2	1920	10	7						2.4				77
8/9/90	1145	7.8	1680	9.6	6						1.7				82
8/16/90	1100	9.8	1390	6.3	4						1.1				73
8/31/90	745	8.2	1210	7.9	4	4	7	8	<5	22	0.94	160	215	290	71
9/2/90	1145	7.1	2870	27	9						2.8	380	720	440	50
9/7/90	1040	7.7	1960	6.3	4						1.1	190	260	300	72
9/14/90	1105	8.5	1220	3.6	4						0.75				72
9/21/90	715	7.2	1330	9.1	4						1.2				69
9/28/90		7.6	1280	6.4	6	4	5	6	<5	19	1.1	150	220	270	70
MIN		6.4	1210	3.6	4	1	4	5	<5	6	0.75	150	215	130	42
MED		7.8	2335	15	7	4	10	9	<5	15	2.3	340	525	515	67
MAX		9.9	4050	36	29	11	16	16	<5	28	3.7	590	820	1000	82
COUNT		49	50	50	48	19	20	19	19	19	49	31	31	31	48

GWD WY 90

Name	Size	Kind	Label	Last Modified
▽ APPENDICES	—	folder	—	Tue, Dec 3, 1991, 12:23 PM
APPENDIX A TITLE	4K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:28 PM
APPENDIX B TITLE	3K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:30 PM
APPENDIX C TITLE	4K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:31 PM
MER 501	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:59 PM
MER 502	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:00 PM
MER 504	8K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:02 PM
MER 505	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:57 PM
MER 506	5K	Microsoft Excel do...	—	Tue, Jan 15, 1991, 8:30 AM
MER 509	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:07 PM
MER 510	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:10 PM
MER 521	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:13 PM
MER 527	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:16 PM
MER 528	7K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:19 PM
MER 531	17K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:31 PM
MER 541	17K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:49 AM
MER 551	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:56 AM
MER 552	5K	Microsoft Excel do...	—	Tue, Jan 29, 1991, 5:11 PM
MER 554	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:58 AM
MER 555	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:01 AM
MER 556	8K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:04 AM
▽ DATA (for figures)	—	folder	—	Fri, Feb 1, 1991, 10:54 AM
d B/ MUD 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 3:03 PM
d JEC/BORON-MO	3K	Cricket Graph docu...	—	Tue, Jan 22, 1991, 4:42 PM
d salt/ b 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 2:38 PM
d salt/se 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 2:19 PM
d se for salt, mud 90	2K	Cricket Graph docu...	—	Thu, Jan 10, 1991, 1:19 PM
d se/ mud 6,8,0	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 3:18 PM
TSW's fine data	1K	Cricket Graph docu...	—	Thu, Jan 31, 1991, 4:54 PM
TSW's Smashing Format	1K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 10:22 AM
▽ FIGURES	—	folder	—	Fri, Feb 1, 1991, 10:52 AM
GWD 90 FIG. 3	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:27 AM
GWD 90 FIG. 4	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:28 AM
GWD 90 FIG. 5	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:15 AM
GWD 90 FIG. 6	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:16 AM
GWD 90 FIG. 7	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:27 AM
GWD 90 FIG. 8	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:27 AM
GWD 90 FIG. 9	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:14 AM
▽ TABLES	—	folder	—	Fri, Feb 1, 1991, 2:18 PM
GWD 90 Table 1	6K	Microsoft Excel do...	—	Wed, Jan 30, 1991, 8:22 AM
GWD 90 Table 2	12K	Microsoft Excel do...	—	Wed, Jan 23, 1991, 9:15 AM
GWD 90 Table 2 v.2	12K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 2:18 PM
GWD 90 Table 3	25K	Microsoft Excel do...	—	Tue, Feb 12, 1991, 1:58 PM
GWD 90 Table 4	3K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 12:06 PM

Name	Size	Kind	Label	Last Modified
APPENDICES	—	folder	—	Tue, Feb 12, 1991, 1:48 PM
APPENDIX A TITLE	4K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:28 PM
APPENDIX B TITLE	3K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:30 PM
APPENDIX C TITLE	4K	Microsoft Excel do...	—	Tue, Feb 19, 1991, 12:31 PM
MER 501	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:59 PM
MER 502	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:00 PM
MER 504	8K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:02 PM
MER 505	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:57 PM
MER 506	5K	Microsoft Excel do...	—	Tue, Jan 15, 1991, 8:30 AM
MER 509	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:07 PM
MER 510	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:10 PM
MER 521	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:13 PM
MER 527	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:16 PM
MER 528	7K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:19 PM
MER 531	17K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:31 PM
MER 541	17K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:49 AM
MER 551	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:56 AM
MER 552	5K	Microsoft Excel do...	—	Tue, Jan 29, 1991, 5:11 PM
MER 554	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:58 AM
MER 555	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:01 AM
MER 556	8K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:04 AM
DATA (for figures)	—	folder	—	Fri, Feb 1, 1991, 10:54 AM
d B/ MUD 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 3:03 PM
d JEC/BORON-MO	3K	Cricket Graph docu...	—	Tue, Jan 22, 1991, 4:42 PM
d salt/ b 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 2:38 PM
d salt/se 680	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 2:19 PM
d se for salt, mud 90	2K	Cricket Graph docu...	—	Thu, Jan 10, 1991, 1:19 PM
d se/ mud 6,8,0	3K	Cricket Graph docu...	—	Wed, Jan 9, 1991, 3:18 PM
TSW's fine data	1K	Cricket Graph docu...	—	Thu, Jan 31, 1991, 4:54 PM
TSW's Smashing Format	1K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 10:22 AM
FIGURES	—	folder	—	Fri, Feb 1, 1991, 10:52 AM
GWD 90 FIG. 3	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:27 AM
GWD 90 FIG. 4	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:28 AM
GWD 90 FIG. 5	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:15 AM
GWD 90 FIG. 6	4K	Cricket Graph docu...	—	Wed, Jan 30, 1991, 11:16 AM
GWD 90 FIG. 7	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:27 AM
GWD 90 FIG. 8	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:27 AM
GWD 90 FIG. 9	3K	Cricket Graph docu...	—	Fri, Feb 1, 1991, 10:14 AM
GWD 90 CAE	—	folder	—	Thu, Sep 26, 1991, 9:27 AM
Dissolved TE. WY 90/ T. 7	6K	Microsoft Excel do...	—	Thu, Jan 24, 1991, 10:03 AM
fig 3/ss lander (data)	6K	Microsoft Excel do...	—	Tue, Jan 8, 1991, 2:14 PM
fig 5/ mud slo (data)	6K	Microsoft Excel do...	—	Tue, Jan 8, 1991, 2:26 PM
L1MER501.WK1 (Excel2)	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:59 PM
L1MER502.WK1 (Excel2)	10K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:00 PM
L1MER504.WK1 (Excel2)	8K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:02 PM
L1MER505.WK1 (Excel2)	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 3:57 PM

Name	Size	Kind	Label	Last Modified
L1MER506.WK1 (Excel2)	5K	Microsoft Excel do...	—	Tue, Jan 15, 1991, 8:30 AM
L1MER509.WK1 (Excel2)	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:07 PM
L1MER510.WK1 (Excel2)	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:10 PM
L1MER521.WK1 (Excel2)	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:13 PM
L1MER527.WK1 (Excel2)	6K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:16 PM
L1MER528.WK1 (Excel2)	7K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:19 PM
L1MER531.WK1 (Excel2)	17K	Microsoft Excel do...	—	Thu, Jan 31, 1991, 4:31 PM
L1MER541.WK1 (Excel2)	17K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:49 AM
L1MER551.WK1 (Excel2)	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:56 AM
L1MER552.WK1 (Excel2)	5K	Microsoft Excel do...	—	Tue, Jan 29, 1991, 5:11 PM
L1MER554.WK1 (Excel2)	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 7:58 AM
L1MER555.WK1 (Excel2)	6K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:01 AM
L1MER556.WK1 (Excel2)	8K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 8:04 AM
TABLES	—	folder	—	Fri, Feb 1, 1991, 2:18 PM
GWD 90 Table 1	6K	Microsoft Excel do...	—	Wed, Jan 30, 1991, 8:22 AM
GWD 90 Table 2	12K	Microsoft Excel do...	—	Wed, Jan 23, 1991, 9:15 AM
GWD 90 Table 2 v.2	12K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 2:18 PM
GWD 90 Table 3	25K	Microsoft Excel do...	—	Tue, Feb 12, 1991, 1:58 PM
GWD 90 Table 4	3K	Microsoft Excel do...	—	Fri, Feb 1, 1991, 12:06 PM

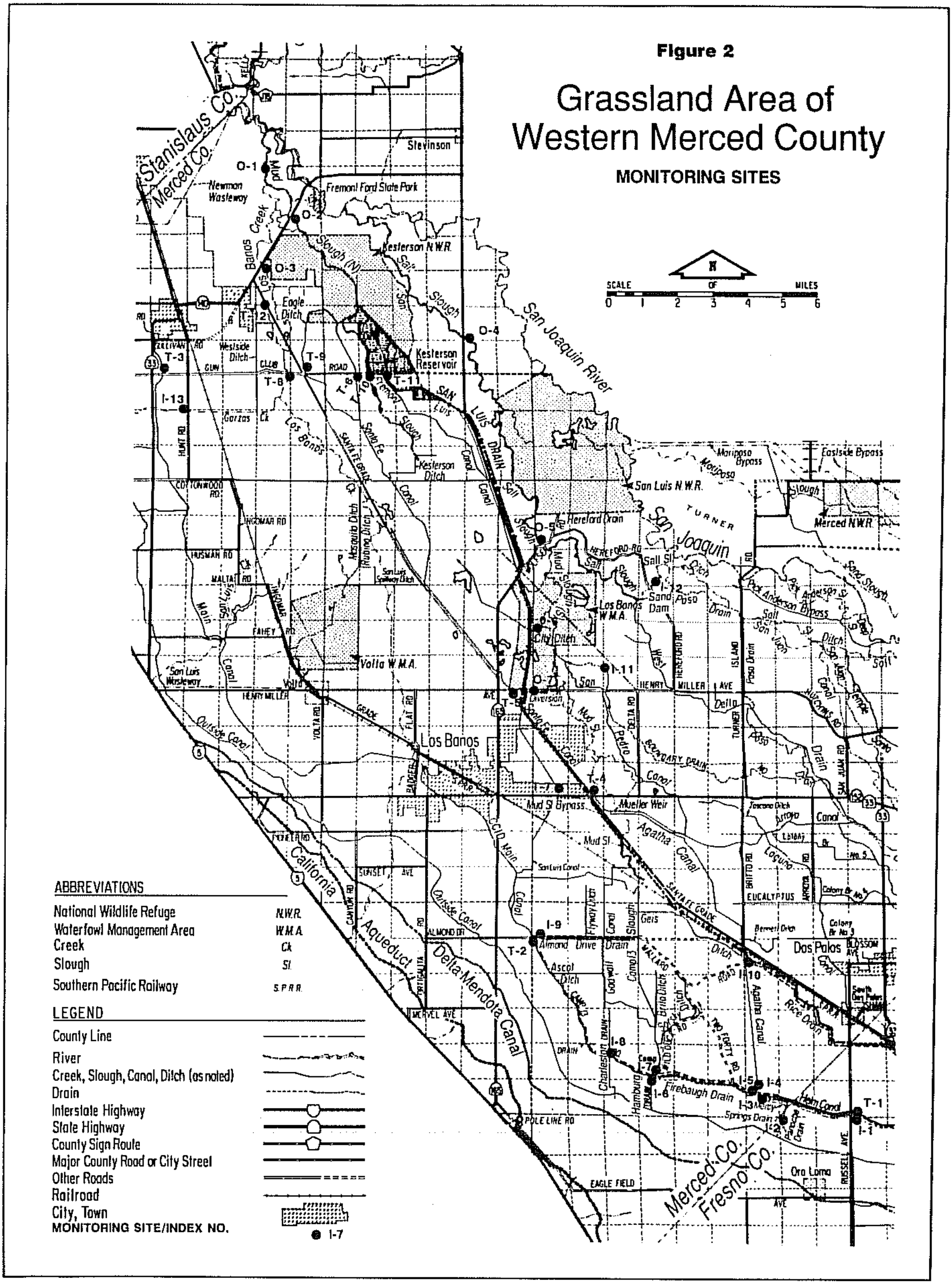


Figure 2

Grassland Area of Western Merced County

MONITORING SITES

Table 1. Water Quality Monitoring Sites in the Grassland Area
(adapted from James et al., 1988 and Chilcott et al., 1989).

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	**MER556**	**Main (Firebaugh) Drain @ Russell**	**Inflow**
I-2	**MER501**	**Panoche Drain**	**Inflow**
I-3	**MER552**	**Agatha Inlet (Mercy Springs) Drain**	**Inflow**
I-4	**MER506**	**Agatha Canal**	**Inflow**
I-5	MER507	Helm Canal	Inflow
I-6	**MER504**	**Hamburg Drain**	**Inflow**
I-7	**MER505**	**Camp 13 Slough**	**Inflow**
I-8	**MER502**	**Charleston Drain**	**Inflow**
I-9	**MER555**	**Almond Drive Drain**	**Inflow**
I-10	**MER509**	**Rice Drain**	**Inflow**
I-11	**MER521**	**Boundary Drain**	**Inflow**
I-12	**MER528**	**Salt Slough Ditch @ Hereford Road**	**Inflow**
I-13	MER513	Garzas Creek @ Hunt Road	Inflow
T-1	**MER510**	**CCID Main @ Russell Avenue**	**Internal Flow**
T-2	MER511	CCID Main @ Almond Drive	Internal Flow
T-3	MER512	CCID Main @ Gun Club Road	Internal Flow
T-4	MER540	Santa Fe Canal @ HWY 152	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Rd.	Internal Flow
T-6	MER517	Santa Fe Canal @ Gun Club Rd.	Internal Flow
T-7	**MER527**	**San Luis Canal @ HWY 152**	**Internal Flow**
T-8	MER514	Los Banos Creek @ Gun Club Rd.	Internal Flow
T-9	MER518	Eagle Ditch	Internal Flow
T-10	MER516	Mud Slough (North) @ Gun Club Rd.	Internal Flow
T-11	MER515	Freemont Canal @ Gun Club Rd.	Internal Flow
T-12	MER553	Gustine Sewage Treatment Plant Ditch	Internal Flow
O-1	**MER551**	**Mud Slough (N) @ Newman Gun Club**	**Outflow**
O-2	**MER541**	**Mud Slough (N) @ HWY 140**	**Outflow**
O-3	**MER554**	**Los Banos Creek @ HWY 140**	**Outflow**
O-4	**MER531**	**Salt Slough @ Lander Avenue**	**Outflow**
O-5	MER530	Salt Slough @ Wolfsen Road	Outflow
O-6	MER543	City Ditch	Outflow
O-7	MER548	Santa Fe Canal-Mud Slough Diversion	Outflow

Bold print indicates that site has data for WY 90

METHODS

The frequency of sample collection for this phase of the monitoring program varied, but generally grab samples were collected during the first week of each month and were analyzed for total recoverable selenium, boron, chloride, sulfate, hardness and electrical conductivity (EC). Because of the continued drought conditions throughout WY 90, weekly sampling was conducted at outflow sites O-2 and O-4 (Table 1). Selected inflow and outflow monitoring sites were also sampled for total recoverable copper, chromium, lead, molybdenum, nickel, and zinc. Water temperature, pH, EC, and sample time were recorded in the field for each site. All samples were collected in polyethylene bottles. All the selenium and trace element sample bottles were washed and acid rinsed in the laboratory prior to use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium and trace element samples were preserved by lowering the pH to less than 2 using ultra-pure nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.

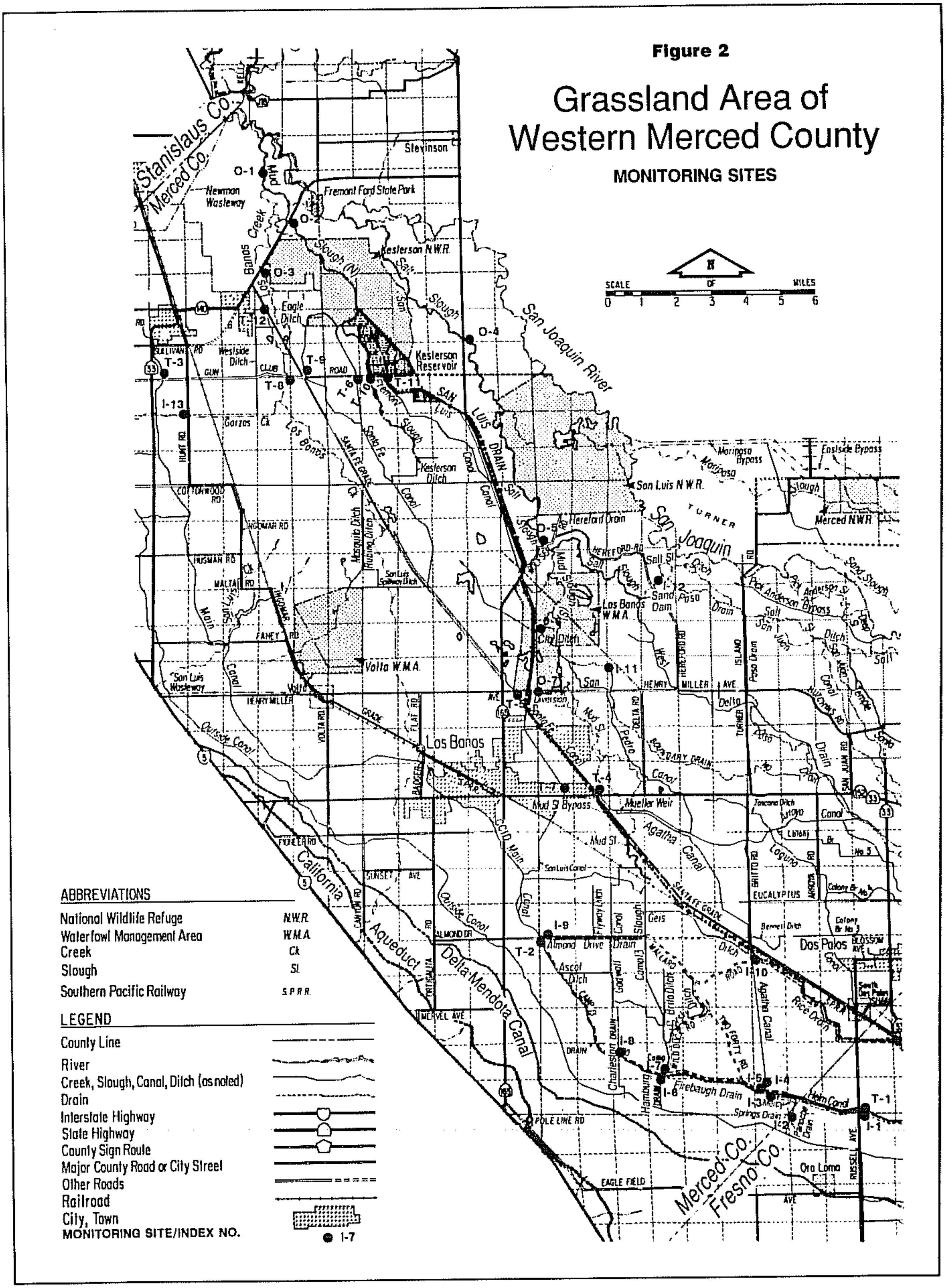


Figure 2
Grassland Area of Western Merced County
MONITORING SITES
SCALE OF MILES
0 1 2 3 4 5 6
N
ABBREVIATIONS
National Wildlife Refuge N.W.R.
Waterfowl Management Area W.M.A.
Creek Ck.
Slough Sl.
Southern Pacific Railway S.P.R.R.
LEGEND
County Line
River
Creek, Slough, Canal, Ditch (as noted)
Drain
Interstate Highway
State Highway
County Sign Route
Major County Road or City Street
Other Roads
Railroad
City, Town
MONITORING SITE/INDEX NO.
I-7
Stanislaus Co.
Merced Co.
Merced Co.
Fresno Co.
Stevinson
Fremont Ford State Park
Newman Wasteway
Kesterson N.W.R.
Kesterson Reservoir
San Joaquin River
San Luis N.W.R.
Merced N.W.R.
Los Banos W.M.A.
Volta W.M.A.
Los Banos
Dos Palos
Oro Loma
California Aqueduct
Delta-Mendota Canal
San Luis Drain
Mud Slough
Salt Slough
Firebaugh Drain
Agatha Canal
O-1
O-2
O-3
O-4
O-5
O-7
T-1
T-2
T-3
T-4
T-8
T-9
I-1
I-4
I-8
I-9
I-10
I-11
I-13

Table 1. Water Quality Monitoring Sites in the Grassland Area (adapted from James et al., 1988 and Chilcott et al., 1989).

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	**MER556**	**Main (Firebaugh) Drain @ Russell**	**Inflow**
I-2	**MER501**	**Panoche Drain**	**Inflow**
I-3	**MER552**	**Agatha Inlet (Mercy Springs) Drain**	**Inflow**
I-4	**MER506**	**Agatha Canal**	**Inflow**
I-5	MER507	Helm Canal	Inflow
I-6	**MER504**	**Hamburg Drain**	**Inflow**
I-7	**MER505**	**Camp 13 Slough**	**Inflow**
I-8	**MER502**	**Charleston Drain**	**Inflow**
I-9	**MER555**	**Almond Drive Drain**	**Inflow**
I-10	**MER509**	**Rice Drain**	**Inflow**
I-11	**MER521**	**Boundary Drain**	**Inflow**
I-12	**MER528**	**Salt Slough Ditch @ Hereford Road**	**Inflow**
I-13	MER513	Garzas Creek @ Hunt Road	Inflow
T-1	**MER510**	**CCID Main @ Russell Avenue**	**Internal Flow**
T-2	MER511	CCID Main @ Almond Drive	Internal Flow
T-3	MER512	CCID Main @ Gun Club Road	Internal Flow
T-4	MER540	Santa Fe Canal @ HWY 152	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Rd.	Internal Flow
T-6	MER517	Santa Fe Canal @ Gun Club Rd.	Internal Flow
T-7	**MER527**	**San Luis Canal @ HWY 152**	**Internal Flow**
T-8	MER514	Los Banos Creek @ Gun Club Rd.	Internal Flow
T-9	MER518	Eagle Ditch	Internal Flow
T-10	MER516	Mud Slough (North) @ Gun Club Rd.	Internal Flow
T-11	MER515	Freemont Canal @ Gun Club Rd.	Internal Flow
T-12	MER553	Gustine Sewage Treatment Plant Ditch	Internal Flow
O-1	**MER551**	**Mud Slough (N) @ Newman Gun Club**	**Outflow**
O-2	**MER541**	**Mud Slough (N) @ HWY 140**	**Outflow**
O-3	**MER554**	**Los Banos Creek @ HWY 140**	**Outflow**
O-4	**MER531**	**Salt Slough @ Lander Avenue**	**Outflow**
O-5	MER530	Salt Slough @ Wolfsen Road	Outflow
O-6	MER543	City Ditch	Outflow
O-7	MER548	Santa Fe Canal-Mud Slough Diversion	Outflow

Bold print indicates that site has data for WY 90

METHODS

The frequency of sample collection for this phase of the monitoring program varied, but generally grab samples were collected during the first week of each month and were analyzed for total recoverable selenium, boron, chloride, sulfate, hardness and electrical conductivity (EC). Because of the continued drought conditions throughout WY 90, weekly sampling was conducted at outflow sites 0-2 and 0-4 (Table 1). Selected inflow and outflow monitoring sites were also sampled for total recoverable copper, chromium, lead, molybdenum, nickel, and zinc. Water temperature, pH, EC, and sample time were recorded in the field for each site. All samples were collected in polyethylene bottles. All the selenium and trace element sample bottles were washed and acid rinsed in the laboratory prior to use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium and trace element samples were preserved by lowering the pH to less than 2 using ultra-pure nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.